SCIENCE CLEARS MARY STUART

DISCOVERY

A Monthly Popular Journal of Knowledge

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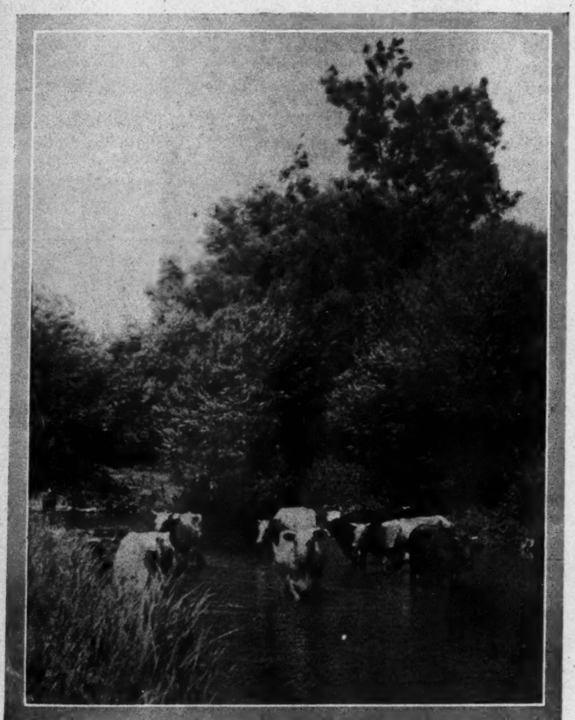

THE RIGHT KIND OF JUNE

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Edited by HUGH B. C. POLLARD.

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Editorial Notes.

EIGHTEEN hundred and twenty-five must have been rather an interesting period to live in. This year's centenaries—the discovery of benzene, the invention of railroad locomotives—take us back to an era of nascent science and, if one may believe ingenious historians, shocking industrial iniquities. On the other hand, it is doubtful if many among the crowds of beaver-hatted nankeen-trousered fashionables of that day had the slightest appreciation of the work of their engineers and natural philosophers. The science "boom" of the last century appears to have taken definite shape by 1840, and culminated in the Exhibition of 1851. Reaction seems to have set in during the sixties, and with occasional oscillations produced by some new popular marvel, public interest descended to our modern temperate apathy. To-day we accept any new development as a convenience, but it is not many people who are interested in either the research work or the ingenious chemical or manufacturing processes which have made the new thing possible. The student of history has not yet revealed to us why at certain past periods the general educated public suddenly became infected with an inquiring mind. The scientists and engineers, like ants, are always working. Progress is made nowadays at a relatively rapid rate. Means of communication and means of disseminating knowledge have become far more speedy. Books of sound potted science are in great demand, and the opportunities for education are in excess of the wildest Utopian dreams of an earnest-minded Jacobin of a century ago. Yet at the moment a something, a quickening spirit of curiosity, a general public interest, is not manifest in the same intensity as it undoubtedly has been in the past. It is coming; not perhaps immediately, but more quickly than many people would anticipate. Both science and applied science (for nowadays there is no definable frontier between them) need publicity. It is not enough that scientific work should be regarded as a benignant or a malefic mystery accomplished by clever but peculiar people. The functions of the sciences and sub-sciences as they affect public welfare and personal welfare need to be insistently told and retold again. Not only the younger generation but the present adult generation must be brought to realize the tremendous effect of scientific knowledge and method on everyday aspects of life.

* * * * *

A good beginning has been made with this type of publicity in the Chemical Industries Section at Wembley. Last year the exhibits tended to fall into two categories—prize crystals in bottles which are not after all very seductive attractions to either layman or chemist, or models of ideal molecules made out of coloured wax balls on knitting needles. These too did not convince a public all too prone to confuse a molecule with a microbe. This year chemistry is not only far more intelligible, but there is some entertaining window-dressing: tanks with goldfish unscathed among water passing in cascade over tar—a matter of interest to all good anglers and road surveyors; the "Jack Tar" Inn with a tree in which a pair of rare aniline birds sing melodiously. This, the austere chemist may say, is playing to the gallery—thank goodness it is. The whole point of an exhibition is to arrest attention, to make them stop, look and listen—to get them interested. The casual visitor who takes goldfish bait may wander to the next case where a block of coal is the apex of a pyramid of ribbons, each of which leads to some material made of coal by-products. The lesson is conveyed not as

a cold diagram, but as an object-lesson. Other industries might well take a leaf out of the Chemical Industries book. We apparently make optical glass which is as good as anything produced at Jena. Do we tell the world? It is possible that in a hurried first visit to the Exhibition I missed some attractive display of microscopes, high-aperture camera lenses and some attention-arresting demonstration which would bring this valuable fact home to me. On the other hand I doubt if I should escape from a German exhibition without hearing all about Jena glass and looking through some of it. They do not need to be told that prosperity depends on publicity.

* * * * *

At the Royal Society's conversazione the other day there were many interesting exhibits. One that was peculiarly interesting was that of the Department of Zoology of the British Museum, where Mr. C. Tate Regan, F.R.S., showed some deep-sea angler fishes. These rather unhandsome animals live from five hundred to fifteen hundred yards below the surface, and attract their prey with a luminous bait. They are solitary and relatively slow-swimming. These conditions would render the matrimonial chances of a lady angler fish somewhat hazardous, as without special provisions she could not find a mate. The methods adopted have only just come to light. She carries an inconspicuous husband about permanently attached to her. The female fish is the size of a moderate cod, say over a yard long. The male, poor creature, is smaller than a sardine. He is fitted with a sucker attachment to his lip which enables him to secure himself to his mate. Soon the tissue of the sucker grows into that of the skin of the female and they pass through life inseparably attached. The male, in the hard language of science, is parasitic upon the female. It is thought that the attachment takes place soon after the male is hatched, when young males are relatively numerous. Had this discovery been made before the war, what play some of our most ardent feminists might have made with it! Another exhibit of considerable interest was an electrical audiometer made by the International Western Electric Co. This machine enables the operator to test the sensitivity of any ear in relation to a definite normal datum line determined by experiment from a large number of normal people. In practice it is useful for gauging degrees of deafness and in particular for diagnosing specific causes of deafness owing to failure to respond to certain definite sound frequencies. I am inclined to think that it has a further use, for here is an instrument which might well be used in the interests of science to find out whether Professor Gilbert Murray has actually a gift of telepathy or whether this is, as has been suggested, simply supersensitive hearing. I commend this suggestion to the Society for Psychical Research if they have not tried it already.

BORIC ACID AND THE SKIN.

From the rate of diffusion or penetration of boric acid through the skin it has been shown that dead and live skin are chemically different, also the skin of mucous membranes are different from the rest of the surface of the body. It is well known that boric acid compresses applied to the skin are very beneficial in cases of blood poisoning. This is because the acid is readily absorbed by the skin and passed into the blood stream where it immediately attacks the poison and aids the elimination of the latter through the ordinary channels.

THE PRINCE AND SCIENCE.

It is officially announced that the Prince of Wales has accepted the presidency of the British Association for the Advancement of Science for the Oxford Meeting in 1926.

The Prince Consort, whose precedent the Prince of Wales will follow, presided over the association in 1859 at Aberdeen. In his presidential address, which lasted for about three-quarters of an hour, he stated his reason for accepting office: "Remembering that this association is a popular association, not a secret confraternity of men jealously guarding the mysteries of their profession, but inviting the uninitiated, the public at large, to join them, having as one of its objects to break down those imaginary and hurtful barriers which exist between men of science and so-called men of practice—I felt that I could, from the peculiar position in which Providence has placed me in this country, appear as the representative of that large public which profits by and admires your exertions." He conveyed a message to science from the Queen, and surveyed the then recent fields of scientific advancement in which the association had taken part to the public benefit.

The Prince of Wales will succeed Professor Horace Lamb, who is to preside over this year's meeting of the association in Southampton from 26th August to 2nd September.

The Spurious Marriage Contract of Mary Stuart.

By C. Ainsworth Mitchell, M.A., F.I.C.

Rival historians have long discussed the authenticity of the famous Casket Letters which cost Mary Stuart her head. The author, the celebrated expert on the identification of handwriting, concludes that modern scientific research clearly points to their having been forged by Mary's secretary, Maitland of Lethington. If so, Mary was wrongly condemned.

On Sunday, 16th May, 1568, Mary, Queen of Scots, took the fateful step that put her in the power of Queen Elizabeth. Fleeing south from the battlefield of Langside, where she had watched the shattering of her hopes of immediately regaining the crown, she recalled the many messages of sympathy sent to her by Queen Elizabeth during her captivity at Lochleven, and felt that her best plan was to appeal in person for the help against her rebel lords which had been so often promised. And so with a few attendants she sailed across the Solway in an open fishing boat from Dundrennan in Galloway, and landed the same evening at Workington in Cumberland. The forebodings of some of her friends were borne out by the event: she never saw Scotland again.

Fig 1.
MARY QUEEN OF SCOTS IN 1562.

The unexpected presence of the Queen of Scots on English soil created a very difficult problem for Elizabeth. She had now to decide whether she would support Mary's cause and so help to restore to power a rival who still claimed the English throne, or whether she would let her go to France and there become the nucleus round which successive plots against England would gather. Mary had reckoned with confidence upon one or other of these alternatives, but Elizabeth chose neither. Acting upon the advice of her minister, Cecil, she sent further messages of sympathy and promises of future help, provided that Mary could prove to her that there was no truth in the charge that she had had any part in the murder of her husband, Darnley. Mary eagerly undertook to do this if Elizabeth would grant her an interview. But Elizabeth replied that she could not see her until the charges had been disproved, that she hoped this would soon be done, and that with this end in view she was appointing Commissioners who would examine and report upon them.

For some time Mary angrily refused to have anything to do with such a Commission. It was not fitting, she protested, that she, a sovereign princess, should be forced to plead her cause before the subjects of another sovereign; but to this Elizabeth replied that it was not the Queen of Scots who was to defend herself, but the Regent Murray and the other Scottish nobles who were to be summoned to England to justify the accusations they had brought against their sovereign, and that, if they failed to do this, she, Elizabeth, pledged her honour that she would restore Mary to her throne. Unable to escape from this network of plausibility, Mary concealed her chagrin and reluctantly appointed Commissioners to represent her at the inquiry, which she had been led to believe would be purely formal.

Elizabeth then sent a peremptory message to Murray to appoint representatives to a Commission at York and to bring with him the proofs of the charges against Queen Mary. The Regent, who was not in a position to quarrel with Elizabeth, ignored the insulting terms of the message, and replied that he would himself attend the Commission and would be accompanied by the Earl of Morton, Lord Lindsay and George Buchanan.

The Duke of Norfolk, the Earl of Sussex, and Sir Ralph Sadler were appointed as the English Commissioners, and Queen Mary named as her repre-

FIG. 2.
JAMES STUART, EARL OF MURRAY.
Born 1533. Natural son of James V. Regent of Scotland 1567. Assassinated 1570.

sentatives five of her adherents who had followed her to England, the chief spokesmen for her being Lord Herries and Leslie, Bishop of Ross.

The three parties assembled at York early in October, and with the Scottish Commissioners came William Maitland of Lethington, who had once been Mary's trusted secretary. The proceedings, which opened on 8th October, were mainly occupied with the moral justification for the action taken by Murray and the other nobles against the Queen. No definite charge was yet formulated against Mary, but Murray privately showed the English Commissioners the written proofs upon which he relied, and stipulated that, before producing them, he required information as to what would be the action of the Queen of England should Mary, Queen of Scots, be found guilty. To this Elizabeth replied that she hoped to be convinced of the innocence of Mary, but that, should the evidence prove her guilty, she, for her part, would deem her unworthy of a throne. She then ordered the Conference to be adjourned to Hampton Court, and added four more members to the Commission, including Sir William Cecil.

The Casket.

Murray still hesitated to proceed to extremes, until on 6th December he was called before the Commission and reproved by them in the name of Queen Elizabeth for the horrible charges brought against his Queen, and asked what reply he had to make. The same day Mary's Commissioners gave notice that, unless their Queen could appear before Queen Elizabeth to answer for herself, they would not take any further part in the proceedings.

Two days later Murray produced the "casket" letters and documents, which have since become notorious. These were read and compared with letters written by Queen Mary to Queen Elizabeth, and copies were made and carefully compared with the originals, which were then returned to the Earl of Morton.

Mary asked, through her Commissioners, to be allowed to see these documents which she was accused of having written. "Gif ony sic Writings be," she wrote, "they are false and feinzeit, forgit and inventet by thameselfis onlie to my dishonour and sclander." This request was refused by the English Commissioners on the ground that Mary herself had put an end to the Conference by refusing to reply to the charges.

A Political Trial.

But although the Conference thus ended without any decision being given, Elizabeth had gained much by it, for she could now plead that Mary had not rebutted the evidence brought against her, and that therefore it was a matter of political necessity to keep her in restraint in England. And so began that long and wearisome captivity which ended seventeen years later with Mary's death by the hand of the headsman at Fotheringay.

Mary was condemned (for the result of the Commission was regarded as her condemnation) mainly upon the circumstantial evidence of these "casket" documents, for although the moral indications were also discussed, they were not considered conclusive by the Commissioners (Hume, chap. xxxix, p. 75-76). If these documents were really written by Mary, no further evidence of her guilt is necessary; hence the importance that has been attached to them by succeeding generations of historians, and the acrimonious dispute that has centred about them. The story of their capture, as told to the Commission on 7th December, 1568, is given by Buchanan in his "Detectioun of the Doingis of Marie Quene of Scottis." It is to the effect that the Earl of Bothwell, after fleeing from Edinburgh Castle, had sent a messenger for "ane small gylt coffer, not fully ane fute lang, being garnischet in sundrie places with the *Romane* Letter F, under ane Kingis crowne; quhairin were certaine letteris and wrytingis well knawin, and be aithes to be affirmit to have been writtin with the Quene of *Scottis* awin hand to the Erle *Bothwell*." The Earl of Morton had seized this messenger, Dalglish, and had kept possession of the casket and its contents.

FIG. 3.
SIR WILLIAM MAITLAND OF LETHINGTON.
Secretary to Mary, Queen of Scots. Accused of forging the Casket Letters. Died 1573 (? suicide)

These included eight love letters alleged to have been written by Mary to Bothwell, twelve love sonnets, a contract of marriage said to be written by the Earl of Huntly, dated April, 1567, and signed by Mary and Bothwell, and another contract or obligation " written by the Queen's awin hand, promising to marry the said Bothwell." (" Murray's Instructions to his Ambassador," Goodall, II, p. 84).

Contemporary Reports.

Of this second contract Buchanan writes, " thair was alswa extant a wryting written in *Romane* hand in *French* to be avowit to be writtin be the said Quene of *Scottis* herself, being ane promeis of marriage to the said Bothwell: Quhilk writing being without dait and thocht sum wordis thairin seme to the contrairie. zit is upon credibile graunds supposit to have been maid and written by hir befoir the deith of hir husband, Ye tenor quhairof thus beginnis :

> 'Nous MARIE, par la grace de Dieu, Royne d'Ecosse, douaryere de France, etc., promettons fidellement de bonne foy, et sans contrayntel à Jacques Hepburn, Conte de Boduel, de n'avoir jamais autre espoulx et mary que luy et de le prendre pour tel toute et quant fois qu'il m'en requerira, quoy que parents, amys ou autres y soient contrayres. Et puis que Dieu a pris mon feu mary, Henry Stuart, dit Darnlay, et que par ce moien je fois libre, n'estant soubt obeissance de pere, ni de mere, des maytenant je proteste que, lui estant en mesme Liberté, je seray preste, d'accomplir les ceremonies requises au mariage : que je lui promets devant Dieu, que j'en prantz à tesmoignage et la presente, signée de ma mayn ; ecrit ce
>
> MARIE R.' "

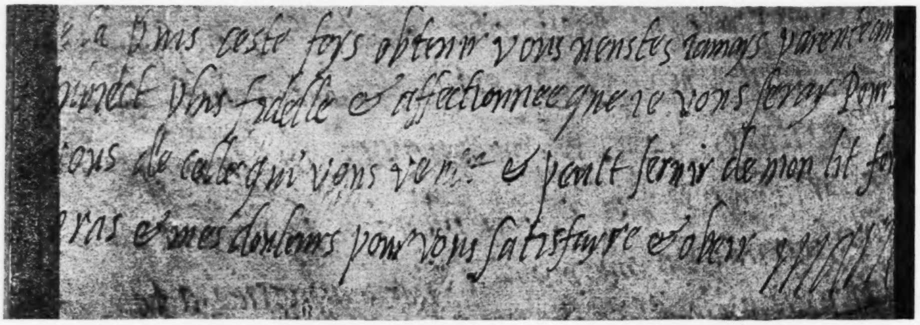
This " contract " was produced by Murray before the Commission on 7th December, 1568, and is specifically mentioned as one of the documents subsequently examined by the Privy Council on 14th December.

Lost Exhibits.

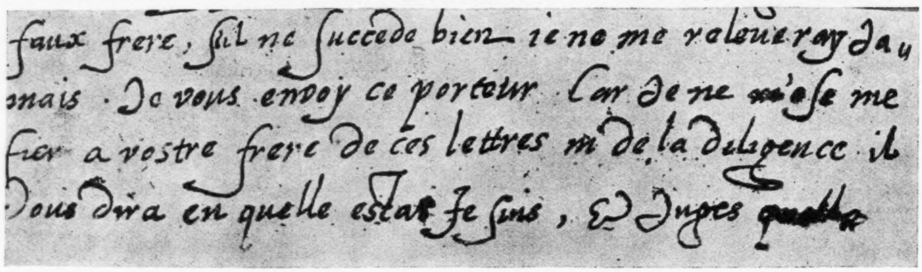
After the Conference, the casket with the original documents disappeared, and the only copies available were Buchanan's Scottish versions, Buchanan's Latin translations of these, and French translations admittedly made from his Latin version. Those who defended the letters asserted that the originals were in French, and the discovery of a French version of two of the letters at Hatfield in 1868 supported this contention. It is noteworthy that, except for the opening sentences, quoted by Buchanan, these Hatfield letters differ in text from the Rochelle French version. Froude discovered two more of these letters in the

FIG. 4.
JAMES DOUGLAS, EARL OF MORTON.
Elected Regent of Scotland 1571. Said to have been tried and executed for participation in the murder of Darnley, 1581.

(a)



(b)



faux frere, s'il ne succede bien ie ne me releueray iamais. Je vous envoy ce porteur car ie ne m'ose me fier a vostre frere de ces lettres ni de la diligence il vous dira en quelle estat je suis, et iuges quelle

(c)

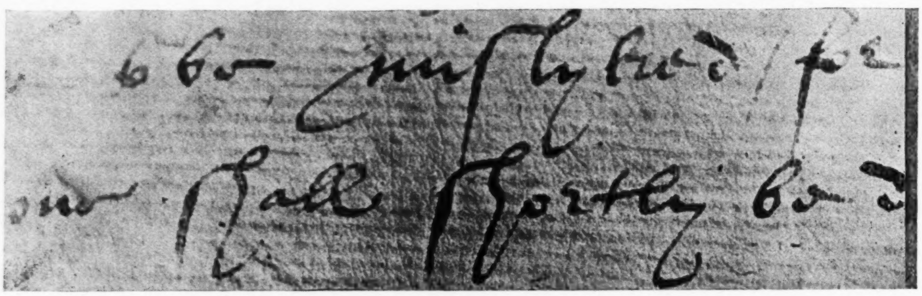


Fig. 5.
(a) Last lines of the "scandal letter" written by Mary to Elizabeth. Hatfield House MS.
(b) Part of the third "casket letter" at Hatfield House.
(c) Part of a letter written by William Maitland of Lethington. Hatfield House.
(*By kind permission of the Marquis of Salisbury.*)

On the other hand, one cannot question Lettenhove's authority on a point of French literature, when he proves by convincing examples that this letter shows neither the style nor the orthography of Mary, and contains grammatical blunders foreign to her writing. In his opinion it is a servile translation of a Scottish text.

Doubt.

The main arguments urged by Hume and Froude in favour of the casket documents being genuine are that they are consistent with Mary's conduct, and that it is improbable that anyone would forge such long letters when a single document would serve the purpose and with less risk of detection. They both overlooked the joy of the craftsman in his work, such as was exemplified at the end of the 18th century when Ireland delighted in deceiving a much wider public than the casket letters had to face, by his extensive literary forgeries, even extending to a whole play of Shakespeare, which was actually produced at Drury Lane.

Both historians point out that the writing was carefully compared with genuine writing of Mary, but neither seems to have been aware of how readily an untrained eye can form a wrong judgment in such a matter. Hume is disingenuous when he remarks ("History of England," chap. xxxix, p. 83): "Bishop Lesley expressly declines the comparing of the hands,

Record Office, and in his History he accepts these as copies of genuine letters written by Queen Mary.

There can be little doubt that both these and the Hatfield letters are copies that were made for the Commission, and compared by them with the original letters, for they show the annotations made by them.

Foreign Views.

There is no evidence in support of Baron de Lettenhove's theory (*Bull. de l'Acad. Royale de Belgique,* 1872, xxxiv, No. 7) that the third letter at Hatfield was the original document produced before the Commission and that it was hurriedly forged by Maitland to represent Mary's handwriting (see Fig. 5, *b*). I have discussed this question elsewhere ("The Expert Witness," p. 176).

which he calls no legal proof." What Leslie did say was that the method of comparison adopted was insufficient for proof: "But who conferred these letters, I pray you, with the Queen's own handwriting? Dare you to warrant them in this so perilous and weighty a cause to have been so exquisitely and so exactly viewed and conferred with all such due circumstance as the law doth require, were it but a civil or money matter?" ("Defence of Mary's Honour," 1571, p. 11). This is a very different thing from Hume's version.

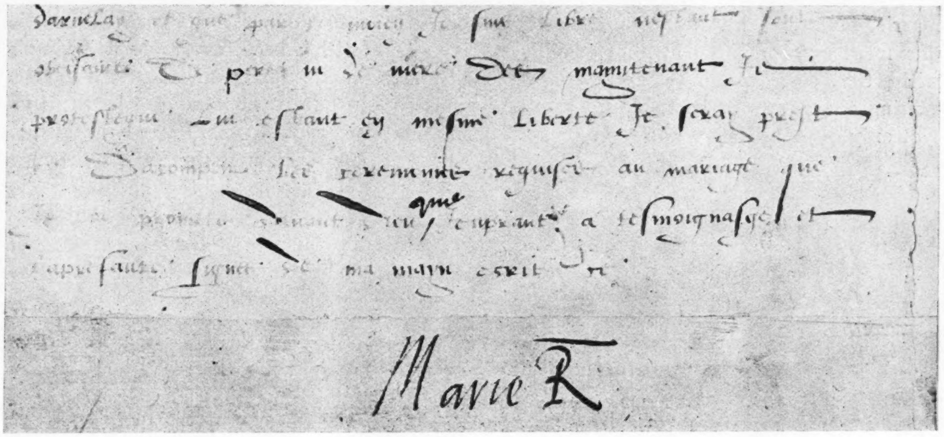


FIG. 6.
LAST PORTION OF THE "FIRST MARRIAGE CONTRACT."
(Brit. Museum, Calig. I, 271).
The signature is here shown much closer to the text than in the original.

Critical Examination.

The whole case of the Scottish Commissioners depended on their proving beyond doubt that the documents produced by them were in the handwriting of Mary, and yet, after being viewed by the Privy Council, these documents were returned to the Earl of Morton and no one was then allowed to examine them again. Apparently even Buchanan no longer had access to them; otherwise he would surely have given the French originals instead of his Scottish and Latin translations when writing his "Detection." For some reason, however, possibly an oversight, the undated promise of marriage termed "the first contract" does not appear to have been returned to Morton, for a document purporting to be the original may still be seen in the MSS. Department of the British Museum. It was accepted as genuine in 1754, for Goodall refers to it, and his statements have never been challenged.

The promise itself is written in an ink that has turned brown with age, and the edges of the lines are of a darker shade of brown. The microscopic appearance of the ink and of the pen lines agrees exactly with that of the signature. A comparison of the writing of the signature with that of genuine signatures of Mary Stuart shows that it cannot be accepted as her writing. As will be seen in the photographic enlargements (Figs. 6 and 7), the formation of the letters, their curves, and their relative heights and positions to the base line are quite different. Obvious dissimilarities in this and the genuine signature are the relative heights of the "M" and the following "a," and the much wider top loop to the "R" in this signature. Mary always made the "M" of relatively the same height as the rest of the signature, and the "R" with very little extension of the upper loop to the left of the line.

The text of the contract also differs markedly from Mary's ordinary cursive writing (Fig. 5), but it is written for the most part in small printed script, and so may conceivably have had some resemblance to script writing of Mary, otherwise it would be difficult to account for the Commissioners' accepting it as in her handwriting. A minute comparison of the mode of formation of the "Roman" characters with those of Mary's handwriting leads to the conclusion that it was not written by her.

The Secret Out.

On studying the text of this document it will be observed that there are frequent lapses into the cursive writing of the period, and as Mary's secretary, Maitland, was accused by his contemporaries of having forged the casket letters, it occurred to me to compare by modern methods of examination these more flowing characters with authentic writing of Maitland. A portion of a characteristic letter of his is shown in Fig. 5*c*, and I am indebted to the Marquis of Salisbury for permission to study and photograph this. At first glance it shows but little resemblance to the text of the

marriage contract, but if the various " lapses " in that document are compared in photographic enlargement with the corresponding characters in Maitland's writing the points of resemblance cannot be missed. Not only do letters show the same mode of formation,

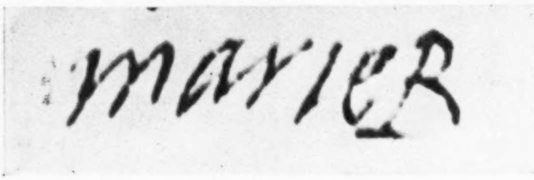


FIG. 7.
NORMAL SIGNATURE OF MARY, QUEEN OF SCOTS.
Enlarged photo of signature on a letter at Hatfield House.

but the method of holding the pen and applying the pen pressure also agree. Some of the very numerous points of agreement are to be seen in Fig. 8, which represents individual letters selected from the two documents. Points that will strike everyone are the resemblances in the different ways of forming the "e," the distinctive "it," and the 13th-century " y " with the characteristic triangle at the top. But more remarkable than any of these is the formation of the "s." Maitland frequently, but not invariably, terminates this letter (and also his "f") in a finely drawn out extension, sometimes even reaching to a letter in the line beneath. This peculiarity (which appears to have been produced by an abrupt alteration in the pen pressure) is also to be found more than once in the marriage contract, and a good example of it is shown in Fig. 8.

The Balance of Evidence.

Many other instances of the resemblances between the writing on this document and in Maitland's letters might be multiplied, as for example in the different forms of " d," the " o's," etc., but those cited are sufficient to prove that whoever wrote the first marriage contract had the characteristics of the writing of Maitland.

As it is highly improbable that there should have been two men at the Conferences at York and Hampton

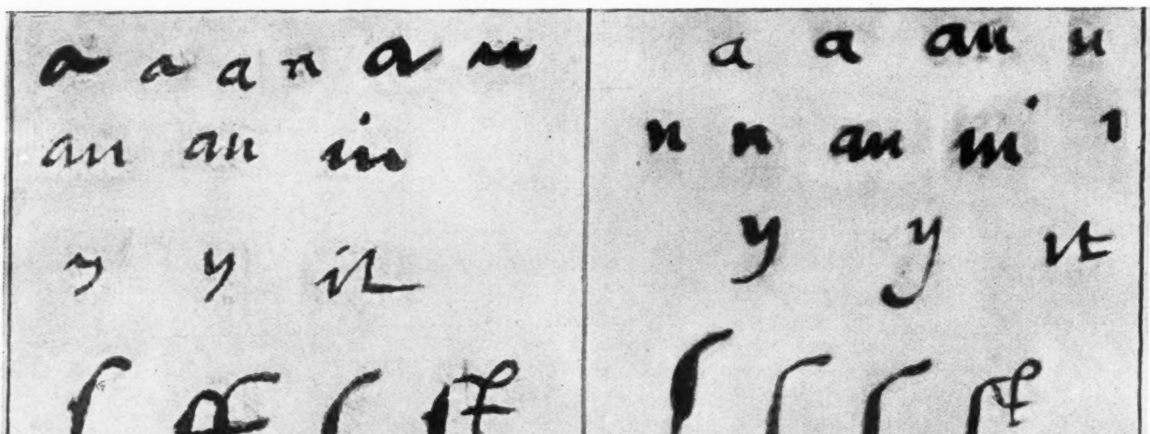


FIG. 8.
WRITING OF MAITLAND. FROM THE MARRIAGE CONTRACT ATTRIBUTED TO MARY STUART.

Court whose writing had the same peculiarities, one can hardly avoid coming to the conclusion that this promise of marriage was written by Maitland. If it is a legitimate copy, why should he, who was attending the Conference as one of Mary's accusers, have made the copy? And would it not have been in his normal handwriting throughout, and not in a mixture of "Roman" and cursive English characters; and would it not have been marked as a copy?

In short, the fact that the only document which tradition asserts to have been one of the original papers in the "casket" has been found to show hidden characteristics of the writing of Maitland is presumptive evidence of the truth of the charges brought against him by Camden and by Bishop Leslie.

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Useful Aspects of Geology. By S. J. SHAND, D.Sc., Ph.D., F.G.S. (Thomas Murby & Co. 7*s.* 6*d.* net).

Elementary Crystallography. By J. W. EVANS, D.Sc., F.R.S., F.G.S., and G. M. DAVIES, M.Sc., F.G.S. (Thomas Murby & Co. 9*s.* 6*d.* net).

Handbook of the Geology of Ireland. By GRENVILLE A. J. COLE, D.Sc., F.R.S., M.R.I.A., and T. HALLISSY, B.A., M.R.I.A. (Thomas Murby & Co. 8*s.* 6*d.* net).

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Magic Food.

By F. A. Hampton.

PRIMITIVE man learns from bitter experience how closely his life depends upon food and, quite logically, he sees a peculiarly intimate connexion between food and the body that is built up from it. He naturally supposes that something of the life that once animated the food passes unchanged into the eater, and upon this idea a vast number of magic beliefs are founded. Hare's flesh is supposed by some races to cause timidity and is avoided by the hunters and warriors ; the flesh of the tiger is prized for the opposite qualities, and it is said that Chinese commanders sometimes issue a ration of dried tiger's heart to their troops before an action in order to enhance their ferocity. Examples could be multiplied without end, but the idea that they illustrate can be studied at first-hand since it persists as a general popular belief to-day and is probably shared, howsoever faintly, by every one of us. It appears in the belief that some food is peculiarly "strengthening,"—that the vigour of an ox can be contained in a teacup—that red meat is more stimulating than white—and in many other more vague discriminations.

Organo-therapy.

These are something more than vulgar errors—the result of a naive logic building upon a false hypothesis—for behind them lies the age-long experience of the race. When the energy value of food was first accurately measured in calories, science endeavoured to persuade an unwilling public to revise its scale of values and to look upon food as little more than fuel for the engine. The timely discovery of vitamins saved us from the worst results of a purely calorimetric diet and introduced an idea that became instantly popular. The concept of vitamin harmonized perfectly with the popular idea that some foods were, in a peculiar way, better than others ; the very word "vitamin," with its suggestion of "life," was happily chosen and reinforced the old folk belief that life was inherent in the food. Scientific theory was reconciled again with popular opinion after their temporary and unnatural divorce.

The recent discovery that the amount of vitamin A in a food, such as animal fat, can be increased by exposing it to sunlight and that sunlight, playing on the individual, produces the same effect as the vitamin, has justified the description of this vitamin A as "stored sunlight." This concept harmonizes perfectly with the semi-religious belief in the sun as the source and quintessence of life, a belief that is true in fact, though often mystical in expression.

Another link between the vitamin theory and popular belief may perhaps exist in the virtues that have been ascribed to almost all non-poisonous plants. In only a very few can a definite pharmacological value be discerned, but all the green herbs that were used in numerous mixture and indefinite quantities may well have been beneficial on account of the antiscorbutic vitamin they contained, since they were chiefly valued in the early spring to correct that "alteration of the blood" from which our forefathers were liable to suffer after a winter's diet in which salt meat and dried peas predominated.

The old magic attitude towards food found many forms of expression in rites and customs. The bond that is created by sharing bread and salt is usually explained as dependent upon the unity created by sharing the food, in this way—that the two individuals have, for the time being, the equivalent of flesh and blood in common and neither can injure the other without at the same time doing harm to himself. Among the Arabs the bond holds for twenty-four hours—as long, that is, as the food remains in the body. Some trace of this belief in a factitious consanguinity, brought about by sharing food, seems to persist in our modern reunion dinners and in much of our hospitality. It is worth noting, although it is not quite germane to the subject, that the practice of blood transfusion has brought to light the existence of several different physiological types of blood, so that the term "blood relationship" expresses a biological fact.

The magic attitude towards food was also reflected in alchemy and we find Paracelsus preparing his celebrated "Homunculus," which restored youth and cured all disorders, by the spagirical digestion of bread and wine, which he held to be the principal food of man. This hope of finding the ideal life-giving food still persists and accounts for the large number of patent foods on the market and the eagerness with which the general public make trial of them. The perfect food, if such exist, might not be able to banish disease, but it is significant that the subject of dietetics is growing in importance, and that new facts have recently been discovered which indicate that diet may be more often a causative factor in disease than was hitherto suspected.

Aphides and their Parasites.

By Mrs. H. Brindley.

Late Research Fellow, Zoology, Newnham.

The green-fly pest is prevalent now. This article tells of the insects that prey on the aphides, and of the other insects who in turn prey on the parasites.

APHIDES, plantlice, or green fly, as they are variously termed, are of evil repute for the damage they do to crops. Luckily for agriculture their extraordinary rate of increase is checked by many natural enemies, predatory and parasitic. Among the latter the most important are certain little insects of the genus *Aphidius*, related to the Ichneumon flies (Hymenoptera).

In a cluster of aphides, certain individuals are pretty certain to catch the eye from their motionless, brown, bloated appearance; and examination with a lens will show that these are nothing but dry empty skins, with a neat round hole cut in the hinder part of the body. This hole has been made by the *Aphidius* murderer of the aphis.

The female *Aphidius* is small and wasp-like, with hyaline wings and a slender flexible body. She herself eats honey, but most of her adult life is spent in providing for the future needs of her carnivorous offspring. She bustles about a crowd of sucking aphides, like a wolf among sheep, and selects a victim by the touch of her vibrating antennæ. Curving her long abdomen forwards, she strikes her ovipositor swiftly into the body of the aphis, and introduces a single minute egg, which is shaped rather like a lemon pip. The aphis struggles a little, but soon settles down to feed again, and the *Aphidius* hurries away to dispose of the rest of her thirty or forty eggs.

The Gardener's Friend.

A day or two later, the *Aphidius* larva is hatched. At first it is a legless, elongated, transparent creature, provided with a curious spiny tail and a pair of curved mandibles; but in the course of its development, which takes about a week, it moults several times, and becomes more and more obese and maggot-like. It feeds, not by gnawing the host's viscera, but in some subtle way by breaking down and ingesting the tissues. The less essential organs, such as the ovaries and fat reserves, are consumed first, and the aphis, which appears scarcely inconvenienced, feeds and moves as usual; but as soon as the parasite is full grown, it gives its host the *coup de grace* by rapidly devouring the intestine and nervous system. Then it neatly lines the empty and inflated skin with a silken cocoon, transforms into a pupa, and emerges about three weeks later as a perfect *Aphidius*.

From the economic point of view, *Aphidius* is one of the gardener's best friends as it kills the destructive green fly; bionomically it is a primary parasite of the aphis. But it is itself liable to the attack of a number of tiny secondary or "hyper"-parasites, which belong to three other divisions of the family Hymenoptera.

One, *Charips*, is a member of the Cynipoidea, which are nearly all gall-makers on plants. *Charips* wanders through the aphis colonies until she finds an individual which has been parasitized by *Aphidius*. Although externally there may be no sign that the aphis is infested, the hyperparasite, with unerring instinct, picks it out from a score of others and leaps upon it.

Hyperparasites.

The aphis, although its doom is sealed in any case, struggles to escape; but *Charips* bestrides it like a rider controlling a restless horse, and, although thrown off again and again, in the end is generally victorious.

The task of the *Charips'* mother is more difficult than that of *Aphidius*. She has not only to penetrate the living body of the aphis, but must grope and probe within it with her ovipositor for the parasite; and even when she has located it, too deep a thrust will force the egg into the enormously distended stomach of the host where it cannot develop. The skill of the *Charips*, however, is such that this seldom happens, and the minute tadpole-shaped egg is extruded safely into the narrow blood-space of the *Aphidius* larva.

The *Aphidius* continues to feed and grow. It consumes the aphis and spins its cocoon; but then its development ceases, for the egg of *Charips* hatches, and the emerging larva preys on its vitals, just as it in turn preyed on the aphis. The young larva of *Charips* is a curious animal, with a long tail and a body encircled with hard dark armoured bands. This heavy coat is presently cast off, and at each successive moult the hyperparasite becomes larger and more maggot-shaped until, when the *Aphidius* has spun its cocoon, *Charips* rapidly devours the remaining tissues and pupates in the aphis skin which the host had prepared for its own use.

Economically, *Charips* is plainly injurious to man since it destroys the beneficial *Aphidius*; and the same may be said of two other hyperparasites, the Chalcid *Asaphes* and the Proctotrypid *Lygocerus*. Unlike *Charips*, these two species feed outside the body of the *Aphidius*, and their life-histories are very similar. The female seeks out an *Aphidius* which has already slain its host and spun a cocoon, and introducing her ovipositor through the aphis skin and silk web, she lays a small elliptical egg on the body of the larva. A small grub hatches from this egg, and crawling over its victim, pierces the delicate skin with its sharp mandibles. The *Aphidius* soon dies, but the hyperparasite ingests the decomposing remains and increases greatly in size. Later it pupates within the cocoon previously woven by the *Aphidius*, and emerges about three weeks later as a perfect insect.

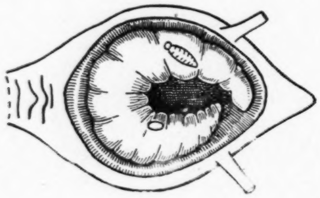


FIG. 1.
A PARASITIZED APHIS OPENED TO SHOW THE LARVA OF *APHIDIUS* WITHIN.
The latter has been attacked by two hyperparasites, and an egg and young larva may be seen on its body.

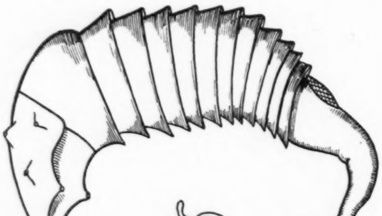


FIG. 2.
THE EGG AND YOUNG LARVA OF THE HYPERPARASITE *CHARIPS*.

The inter-relations of these parasites of a parasite are exceedingly intricate. *Charips* is a comparatively simple case, for it is invariably a parasite of *Aphidius*, and therefore a hyperparasite of the aphis; but the bionomics of *Asaphes* and *Lygocerus* are much more involved. It is possible to find an *Aphidius* which has suffered several successive parasitizations by these forms, and in extreme cases (as in the accompanying diagram) a single aphis may support directly or indirectly at least four kinds of parasites and hyperparasites. Sometimes *Lygocerus* selects a larva previously attacked by one of its own species or by *Asaphes*, or vice versa. These double parasitizations are sometimes called epiparasitization, and the result depends on circumstances. When they involve the internal-living *Charips*, the latter is always killed and eaten by the external forms. When the two latter come into competition, it sometimes happens that the firstcomer is well grown and able to devour the later arrival. In other cases, where the rivals are about the same age, there is not enough food to go round, and both perish. Occasionally, however, an *Asaphes* is killed by one of its own kind or by *Lygocerus*. In such a case it is probable that the mother of the later comer, probing in the cocoon for the *Aphidius*, has found and laid her egg upon the hyperparasite already in possession, and the emerging larva, indiscriminate even to cannibalism, devours the host which accident has provided. The larva of *Lygocerus* rarely suffers in this way, and it has been suggested that its immunity is due to its form. The fully-fed larva of *Asaphes* is a fat immobile maggot; that of *Lygocerus* is provided with a stout caudal appendage, which acts as a lever by means of which the larva can execute active jerky movements within the cocoon. It is possible that when another hyperparasite probes down with its ovipositor, it may be alarmed into withdrawal by the movements of the *Lygocerus* larva below.

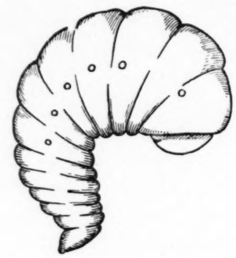


FIG. 3.
THE FULL-GROWN LARVA OF *LYGOCERUS*,
showing the conical appendage at the end of the body.

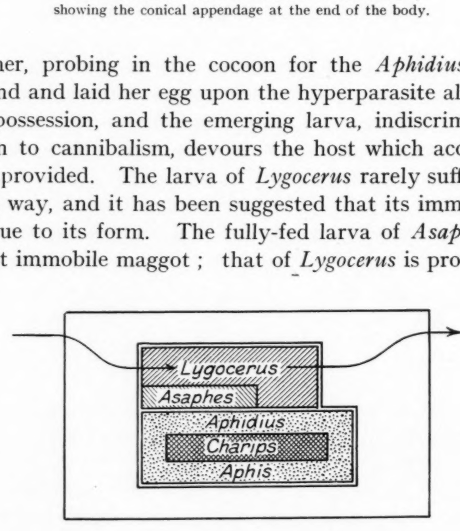


FIG. 4.
In this diagram the outer square represents the aphis. It contains an *Aphidius* (dotted), within which is a *Charips* (cross-hatched). This parasite and hyperparasite are subsequently killed in an attack by *Asaphes* (shaded), and the latter, in its turn, is demolished by *Lygocerus* (shaded), which emerges from the aphis skin successfully.

The bionomics of parasites and hyperparasites are of importance in the modern method of introducing natural enemies to control imported insect pests. This method is not much used in this country, but it has been employed successfully in the United States and elsewhere; and experience has shown that success depends largely on the proper understanding of the bionomical relations of the species concerned. Thus, some years ago, the Mediterranean fruit fly entered Hawaii, and three species of parasite were introduced to check its ravages. Subsequently it was found that two of them, which may be called B and C, could feed not only on the fly larva, but where double parasitization occurred, they took parasite A for a host also. In addition, C was able on occasion to destroy B. This overlapping was the more deplorable in that it was shown that A, where it has a free hand, was really the most efficient fly slayer of the three, since it attacked the host at an early stage; but because it was unable to compete with its rivals in a struggle for the same individual host, it was in a fair way to be suppressed and leave the field to its more omnivorous but, from the point of view of the fruit farmer, less effective colleagues.

John Sargent.

By Archibald Barnes.

An appreciation of the great artist by one of his pupils. He raises the important question of the permanence of the medium with which the artist painted.

WITH the passing of John Sargent the world loses one of her great artists, perhaps the greatest of the moderns. From the time of the production of "Madame Gautreau" and "El Jaleo," to the last picture from his easel, the level of his achievement is amazing. That "Madame Gautreau" should have been hailed with derision and abuse—that the "Misses Vickers" should have been deemed ugly is, in these days, almost incredible. Almost, but not quite, for amidst the welter of trivialities their period produced, the advent of these truths must indeed have been somewhat shocking. Truth is his greatest quality. One forgets the paint, one sees and feels light and air. In some of his greatest portraits, such as the "Henry James," the very man seems to breathe within the frame. In the fine landscapes the sun itself seems to glow. The delicacy of the "Cashmere," the turbulence of the "Branding of the Bull," the glitter of the fountains in the "Italian Garden," owe their beauty to the surest hand and the truest eye of modern times. To say that he produced no bad work would be a preposterous assertion. The life of a fashionable portrait painter is no easy one, and into some of the portraits there does indeed creep a faint ennui, a suspicion of boredom with the subject, that is all the more remarkable when encountered, because of its rarity.

Quantity of Life.

In his best work the vitality is positively unsettling. The figures seem to move, the leaves to rustle; one can almost hear the falling water; very shortly the woman reading must turn the pages of her book.

His output was very great, his versatility extraordinary. Everything fine in art interested him: the vivacity of Hals, the swaggering bravura of Tiepolo, the silvery beauty of Velasquez, the linear magnificence of Raphael. He is amongst the giants and strides with them. Great fellows were the men of the Renaissance—fine painters, great sculptors, splendid decorators: he is their kin. From his brush flowed living men and women.

Variations in Technique.

In his composition he had the extraordinary gift of making it appear that the beauty of design is accidental. There is no apparent striving, no artificial balancing. How lucky to have found a tree just in that place! A rock of just such a shape! In reality, it is a demonstration of tremendous knowledge. His brushwork is superb, and in his best work one inevitably recalls some Hals or Velasquez or Raeburn.

In his portraits the handling of the paint does not vary greatly; his aim seems to have been reached, and he cared to experiment no more. In his smaller work, the landscapes, interiors, architectural studies, the technique varies with almost every picture. Sometimes they are floated on to the canvas with a full liquid brush; at others the paint sparkles with the thick impasto—no ennui here! His intense interest in these studies imparts itself to the onlooker. It is impossible to remain unmoved before the "Branding of the Bull": one breathes more rapidly, as though taking part in the struggle within the gloomy shed. Again, these drowsy recumbent figures beneath the trees—surely the air of the gallery has become warmer?

The handling of some of these small pictures is astounding, even to those whose knowledge of the technical side of painting renders them almost proof against surprise. An intricate swirl of paint, rose, sienna, and blue, seen at its proper distance, becomes a pale, dainty hand. Dabs of blue, brown and gold, apparently shapeless, are transformed into a herd of goats. It is a miracle of vision and execution. It is the same with the architectural studies. No architect could have drawn these slender, fluted columns with greater accuracy, or indicated the complicated foliage of the capitals with greater precision. Yet they are painted with a full, loaded brush, and the thread of sunlight on the edge of the column is achieved with a sweep of the brush from capital to base.

The beauty of Sargent's colour-sense is perhaps best demonstrated in pictures like the "Cashmere." The delicacy of gradations in the flowing shawls of this procession of beauty is delightfully rendered. His picture of the "Hermit" in the Metropolitan Museum is another triumphant example of his sense of colour values. More robust in execution than the "Cashmere," as its size and subject demand, it is conceived and carried to its logical conclusion in so certain a manner, and with such truth, that none but the finest art can live by its side. It is, perhaps, the high-water mark of his achievement in this direction. In the portraits, one feels that it is in his treatment of the blacks that this colour-sense is most remarkable. It requires a great colourist to paint black draperies bathed in light and atmosphere, and his success is almost invariable. Such an early work as "Madame Gautreau" gives as clear a proof of this ability as does any of his later portraits, and this is as it should be. The colourist is born, not made, and no application can remedy the absent sense.

His Best Subjects.

His preference for the cooler colours is very marked in his portraiture, and his happiest effects were usually those in which black, or white, or silver predominated. There are, of course, notable exceptions, and "La Carmencita" is a proof that he could handle the boldest colour schemes with success. A fine example of his more usual coloration is that truly remarkable little picture, "A Venetian Interior," in the Diploma Gallery at Burlington House. The cool gloom of the spacious salon is admirably rendered; it is as true and fine a piece of work as it is possible to conceive, and is an everlasting reproof to the innumerable "clever" little interiors from which no modern exhibition of pictures is immune. Quite apart from its excellent colour, one feels about the picture that it is typical of the man: the polished American was most at ease with such people as this interior contains and in the surroundings depicted.

Though he could paint peasants and inn-keepers with as much apparent interest as he bestowed on the portrait of the greatest aristocrat, one feels that it was with the aristocrat that he was most at home. His art is essentially of the palace, meant to decorate great salons and galleries, and his portraits have an historical value comparable to that of Rubens and Vandyck.

Masterpieces in Danger.

The sum total of his work is so great, his position in modern art so unique, that it is with feelings of the utmost alarm that one stands before work executed only fifteen or twenty years ago. The exhibition of the Wertheimer portraits at the National Gallery was somewhat of a shock to those who remembered them at the time of their first appearance. A certain freshness had already departed, and an amber film seemed to have spread over nearly all. This may be due in part to a somewhat excessive use of linseed oil, in which case the remedy is at hand. Infinitely more alarming is the state of some pictures recently exhibited at Spring Gardens. They are cracking everywhere, and in the case of one of them, which I have not seen for five or six years, the period is sufficient for a very marked progress in deterioration. The cause is not far to seek. Working with a palette that was unexceptionable, the method or the medium alone could cause such devastation in Sargent's pictures.

Happily, with a few exceptions, one can put aside all tales of the improper treatment of his work by their possessors, and it is to the expert one must turn if anything of the original beauty of his work is to be retained. But it must be done immediately, or the sun of his pictures will fade and disappear almost as quickly as the sun itself, and the great men and women of the portraits become but a company of ghosts.

VIENNA, once so celebrated for its musical comedies now appears to export medical comedies as well. Recent rumours suggest that some of the leading lights of the psychological school there have been reviving astrology and that a boom in that particular pseudo science is due shortly. Thus we get back to earlier methods and the casting of nativities will probably be just as popular as the casting out of complexes.

The X-Ray Examination of Coal.

By C. Norman Kemp, B.Sc., and J. Leslie Thomson, B.Sc.

During the last few years great progress has been made with the industrial applications of radiology. Coal and kindred materials can now be analysed by X-rays and special apparatus has been devised.

FROM a certain point of view faith may be defined as the ability to foreshadow and to visualize, more or less completely, conditions which at the time appear definitely, if not permanently, impossible of realization. An admirable example of this is to be found in the prevision of Kelvin, one of whose wellnigh prophetic conclusions was so triumphantly vindicated by the subsequent discovery of radio-activity. The same " eye of faith " has been possessed by innumerable seekers after the elixir of life and the philosophers' stone, and we may infer that many thinkers throughout the ages have speculated as to the possibility of seeing the invisible, even if only in the grossly material sense of seeing to the heart of things concealed from ordinary observation, *i.e.*, things that are opaque or for any reason inaccessible to visual examination.

History.

Professor Röntgen's discovery of " A new kind of ray " has provided science with a " new eye," and one of the writers vividly recalls having heard Professor C. G. Barkla, F.R.S., in his inaugural lecture on appointment to the Chair of Natural Philosophy in the University of Edinburgh, describe the general outlook of a race with eyes directly sensitive to the radiations now generally known as X-rays.

The object of the present article is to deal briefly with a new application of these rays or, more strictly speaking, with the revival and extension of an application first suggested by H. Couriot, Professor of Mining in the Ecole Central des Arts et Manufactures, Paris. In 1898 this distinguished French scientist published a paper in the *Bulletin de la Société de l'Industrie Minérale,* entitled " Examen et Analyse des Combustibles Minéraux," the main purpose of which was to describe and illustrate the results of his experiments on the X-ray examination of coal, based on the observation (to quote his own words) that " les rayons X fournissent un moyen instantané et sûr d'être fixé sur la pureté d'un combustible minéral." Couriot's work does not appear to have been followed up seriously, either by himself or by contemporary or later investigators, till the attention of the present writers was comparatively recently directed to the subject. The earlier experiments were repeated and extended, and a preliminary note published in the *Transactions of the Institute of Mining Engineers* on " The X-ray Analysis of Coal." In the brief historical section of this paper Couriot's work is considered in some detail, and the following statement regarding it may appropriately be quoted: " This communication is certainly entitled to take its place historically as the foundation-stone of whatever edifice may yet be reared thereon, and for ability and thoroughness may fittingly be compared with Röntgen's original paper read only three years previously."

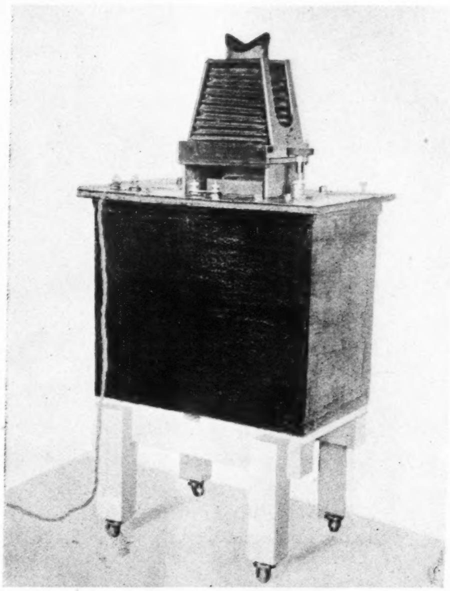


FIG. 1.—THE CARBOSCOPE.
A self-contained X-Ray outfit for the analysis of coal.

Commercial Research.

It is just during the last few years that X-ray technique has developed to a sufficient extent to permit of its effective application as an auxiliary instrument of research in the further investigation of coal, but the results already obtained are interesting and suggestive, and give promise that the work still in progress will yield information both of scientific and of practical value.

As an example in the latter category may be cited the work of W. McLaren on the application of X-ray

methods to the investigation and control of the vitally important industrial process of coal-washing.

For radiographic work the first essential is naturally a source of X-rays, and in the past the equipment for producing these has generally been of the type ordinarily employed by medical workers for diagnostic and therapeutic purposes. Such equipment is necessarily intricate and costly on account of the multiplicity of parts and adjustments required, and of the varied uses to which a single installation must be adaptable. For a technical examining unit, however, the obvious essentials are simplicity and robustness, combined with moderate cost, and such a unit should, above all things, be absolutely "fool-proof," so that even an inexperienced operator is not subjected to risk of accident, either of shock from the high-tension current necessary to generate the X-rays, or of injury from the rays themselves. It is now well known that continued exposure to X-rays may produce effects on the operator which must be guarded against with the most scrupulous care. These are of two kinds :—(1) Visible injuries to the superficial tissues which may result in permanent damage ; (2) Derangements of internal organs and changes in the blood. These are especially important as their earlier manifestation is often unrecognized.

New Apparatus.

A practical unit has been recently designed on the lines indicated, a general view of which is shown in Fig. 1. It consists of a steel tank, filled with a highly-insulating oil, immersed in which are a high-tension transformer and a Coolidge X-ray tube of the radiator type, these being connected together under the oil.

The transformer is of the static, step-up, closed-core type, and in the present instance gives output at 60,000 volts (peak).

The particular X-ray tube employed is now so well known that it need not be described in detail. It is of the hot-cathode type invented by Dr. W. D. Coolidge of the Research Laboratory of the General Electric Company, Schenectady, N.Y., and first placed on the market in 1913. It embodies the first and only fundamental modifications in X-ray tube design and construction since Röntgen's discovery in 1895, and is sometimes referred to as an electron tube in distinction to the original ion tube with which, till 1913, workers had to rest content.

The vitally significant fact which renders possible the evolution of the X-ray unit now under consideration lies in the ability of this particular design of Coolidge tube to act as a rectifier.

Low-voltage alternating current is supplied to the primary winding of the transformer and the secondary output is therefore also alternating. Notwithstanding this, the radiator Coolidge tube is able to suppress the inverse current and permit the passage of direct current only, thus maintaining the correct polarity of the cathode, and so securing the continuous emission of X-radiations from the target of the tube.

Those who have had experience of mechanical and other forms of rectifying devices will appreciate fully the enormous simplification introduced by the self-rectifying Coolidge tube.

FIG. 2.—A TEST SPECIMEN OF COAL.

In the unit under consideration two external terminals only are required, by means of which low-voltage alternating current is supplied to the primary windings of the transformer. The whole outfit is of sound construction, is compact and devoid of adjustments or unnecessary accessories. There are no moving or rotating parts, and the whole is noiseless in action.

Simplicity of Design.

The lid of the tank has near its centre a comparatively small opening through which emerges in an upward direction a cone-shaped beam of X-rays. It is therefore apparent that if any object be placed in the path of this beam and the transmitted radiation examined by means of a suitable fluorescent screen, the projected shadow will reveal the structural details of the object under examination, provided that its thickness or character are not such as to effect the total absorption of the radiation.

If it is desired to obtain an X-ray photograph of a specimen it is only requisite to substitute for the fluorescent screen a photographic plate which, after a short exposure, is developed in the ordinary way.

FIG. 3—X-RAY AT RIGHT ANGLES TO CLEAVAGE.
Showing bands of mineral.

It is, of course, obvious that the most rapid means of obtaining information regarding inner structure is by direct radioscopy, without necessarily involving the photographic process, and perhaps the most valuable character of most X-ray methods, apart from their precision and definiteness, lies in the fact that the results are immediate in the case of visual examinations, and only occupy a few minutes where photography is employed.

How to Interpret.

The ordinary photograph of a lump of a Scottish coal (Fig. 2) shows that the bedding planes are inclined at an angle of rather less than 90° to the cleavage surface on which the specimen is lying. An X-ray photograph taken with the central ray at right angles to this cleavage surface (Fig. 3) shows the typical appearance of a coal radiograph, and reveals what Couriot so aptly described as the " mineral skeleton " of the material. The dark bands across this photograph would suggest the presence of zones of impurity of some considerable width, but it is easy to show that this is due to the projection by the rays of a slightly inclined, thin, intercalated band of ashy matter. If the specimen is tilted through the required angle and another radiograph taken (all other conditions remaining unaltered) it will be noticed that the bands shown in the previous figure resolve themselves practically into lines, being then projected " edge-on." It will be seen from this illustration (Fig. 4) how exceedingly effective a radiographic survey of the interior of an opaque substance can be made, but still further insight may be obtained much more readily by the application of stereoscopic radiography, whereby it is possible to secure the sense of depth associated with ordinary vision, and at the same time to eliminate confusion as to the significance of the dimensions and relative positions of the various portions of the radiograph.

Apart from the quite obvious and definite value of stereoscopy as applied to the X-ray study of numerous opaque substances, there is provided a new series of

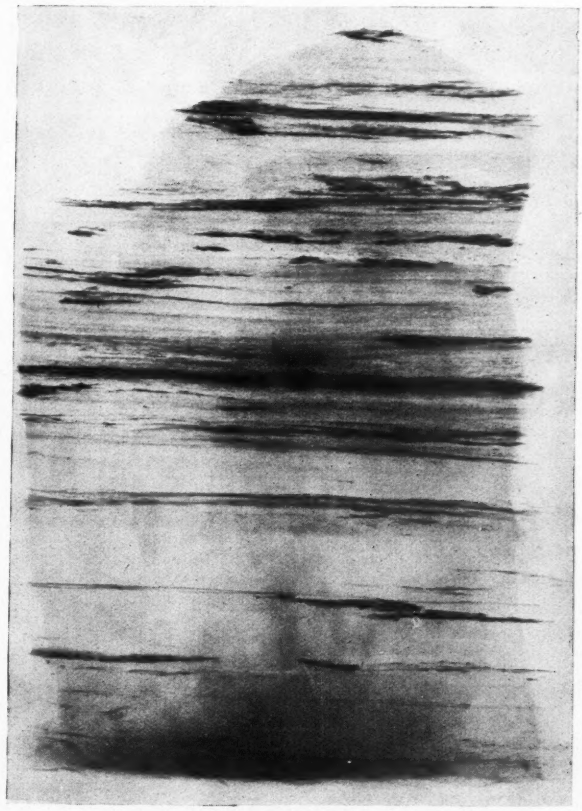
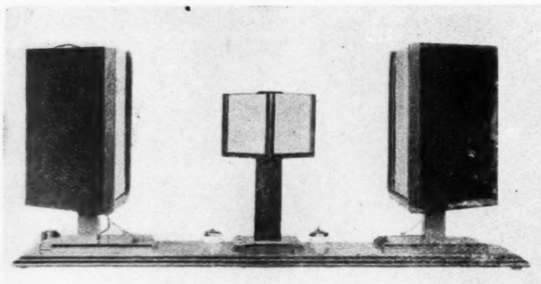


FIG. 4.—THE SAME SPECIMEN TILTED TO AN ANGLE.
Showing that the wide bands in the previous figure are only thin lines.

exceedingly beautiful subjects, many of which amply repay prolonged and detailed study in the stereoscope. Where objects exceed about three inches square the resulting stereoradiographs are viewed by means of a reflecting stereoscope of the type illustrated in Fig 5.

Radiographic examination is particularly effective in the study of coke. While a single print gives a comparatively good idea as to the character of the material, a proper appreciation necessitates the preparation of a stereoscopic pair of prints, when the general impression resembles that of a block of translucent ice with dirty particles suspended heterogeneously therein.



REFLECTING STEREOSCOPE
for viewing the X-Ray prints.

It is customary to regard coal as an opaque material. It may, nevertheless, be studied microscopically by the laborious method of preparing very thin sections, and a vast amount of most important information has thus been obtained, more particularly as regards minute structural details, the investigation of which has shed a flood of light on questions as to the origin and mode of formation of coal measures.

For the macroscopic study of coal, however, X-rays provide a most valuable auxiliary to the chemical, physical, and other methods hitherto employed.

The outstanding feature of X-ray methods lies in the provision of an easy, rapid and non-destructive test of opaque materials, and the possibilities in this field of research are wellnigh unlimited.

Much has appeared in the Press regarding the dangers of X-rays. These are now recognized, and adequate means of protection are known and available. Prospective X-ray workers cannot be too strongly urged to make themselves familiar with the recommendations of the X-ray and Radiation Protection Committee.

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LIQUID OXYGEN AS AN EXPLOSIVE.

GERMANY, during the war, experimented with liquid oxygen as an explosive, but was unable to overcome the problems of transport and ignition. Italian chemists have now, however, succeeded where Germany failed, and find it a most efficient explosive for blasting in mining operations, among other uses. The liquid gas, after suitable purification, is put into cylindrical cartridges consisting of two glass or metal vessels arranged to form a sort of Dewar, or " vacuum " flask. In the end of each cartridge is a hole into which the fuse is fitted ; this is done after the cartridges have been placed in position for firing. When everything is ready a little liquid oxygen is poured over the cartridge and fuse to cool them, and the latter fired either electrically or by hammer detonation.

Three standard types of cartridges have been prepared : cartridge P, equivalent in explosive properties to gunpowder ; cartridge A, of average detonating power ; and D, similar to dynamite. These cartridges have the great advantage of safety after a misfire, since all the oxygen evaporates within thirty minutes, after which the cartridge may be withdrawn without any risk. In explosive power the liquid oxygen is greater than any other explosive known, and, of course, yields no noxious fumes.

Flyfishing and Photography.

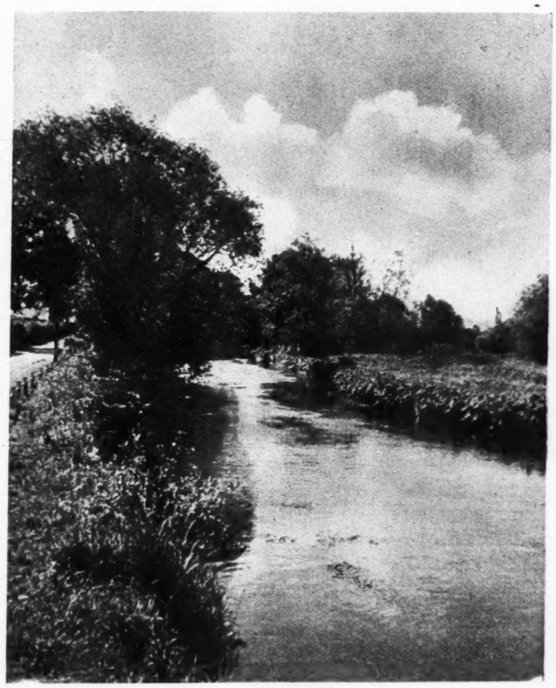
By A. H. Hall, C.B.E., M.I.C.E.

(Photos by the Author).

How you may combine a sport and a hobby. Natural-history photography is not easy. These practical hints from an expert are valuable.

I KNOW of no two hobbies which combine with each other so well as photography and fishing. The true fisherman, whose object is sport, which is by no means measured by the number of fish landed, will rarely find a day when he wants his fly to be on the water all the time.

As a dry-fly fisherman, though I am not one of the purists who sit on the river-bank waiting for a rise of fly, and who consider it a crime to use a fancy fly on the chance of tempting a non-rising fish, I still find the necessity for periods of rest. Especially is this the case when few trout are rising and the occasional fish has to be nursed carefully.



TYPICAL WILTSHIRE CHALK-STREAM SCENERY.
This particular pool has yielded fish over five pounds.

I should regard the photographic opportunities of the wet-fly fisherman as about equal to those of the dry-fly exponent, for though the periods of active fishing may be longer a greater length of the river is usually covered in a given time.

The fishing kit is generally quite extensive enough as it is, and anything elaborate or heavy in the way of cameras would mean that it would be left at home.

Plates Preferable.

A pocket camera of the smallest size is therefore indicated, and for many subjects a roll-film camera is quite suitable, but in my experience it requires more skill to record the beautiful cloud effects and other transient moods of the weather on roll-films than on colour sensitive plates, especially if panchromatic plates are used. As the angler is not likely to make a large number of exposures on any particular day, I should prefer to face the small extra weight of double dark-slides, and in addition have a film pack in an adaptor for emergencies. The details of camera construction are not of importance, except that a lens with an aperture of not less than about f(6) fitted to a shutter which will give slow speeds is advisable, to enable a screen to be used for cloud effects, and to prevent under-exposure in subjects which have near foregrounds, as these will predominate.

A Stand.

The average photographer finds difficulty in holding the camera still enough to make use of the slow speeds, but so many fishermen now carry a folding shooting-seat that this trouble disappears. All that is necessary is to sit on the seat with the elbows resting on the knees and, by holding the camera against the face, an exposure of a quarter of a second becomes a certainty; with a little practice half a second or even more is not difficult.

It will be found, too, that the low view-point is often advisable, and the photographer whose usual aspect of a landscape is from the upright position will be surprised at the number of subjects: he will see when stalking a wary trout on hands and knees. Of course, landscapes are not the only subjects: haymaking and reaping in season, cattle in the meadows and cooling themselves in the stream, other anglers catching fish, weed-cutting, and numerous other pictures are possible.

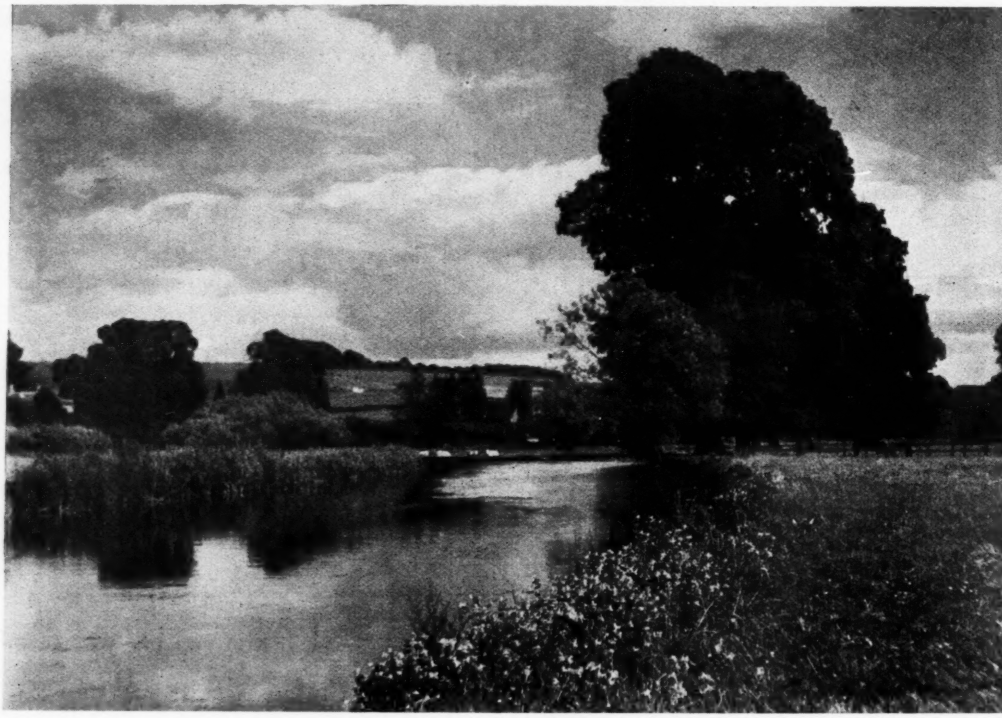
it requires great skill to attempt those natural-history subjects, which are one of the charms of days in the open air, without a stand. I always take one on a fishing holiday, as everyone finds that a rest of a day, or even of an afternoon, will much improve the subsequent fishing, and these periods are often devoted to photographing specimen flowers, or birds' nests, which have been marked down for the purpose.

As regards the landscape subjects, the advantage of being in the open all day allows of the proper lighting for a given subject to be chosen, and the most transient effects of light and shade to be recorded.

There are, of course, the usual failures, but most of them are satisfactory negatives, though each year's results are, from the point of view of selection and technique, better than those of the preceding year.

Think of the Picture.

An intimate knowledge of a piece of country will almost always lead to detail improvements suggesting themselves, and if I am able to visit the river this year I have many subjects already planned in my mind's eye. Of course, lighting and other conditions may be unsuitable, and a projected picture may not be obtained on the first or even second attempt, but that is one of the charms of the work.



JUNE ON A WEST-COUNTRY RIVER.

In the nature of things one is apt to find a good composition at a time when the light is inconvenient, but a little scheming will usually permit the same spot to be visited another day, at a more suitable time, without in any way interfering with the fishing.

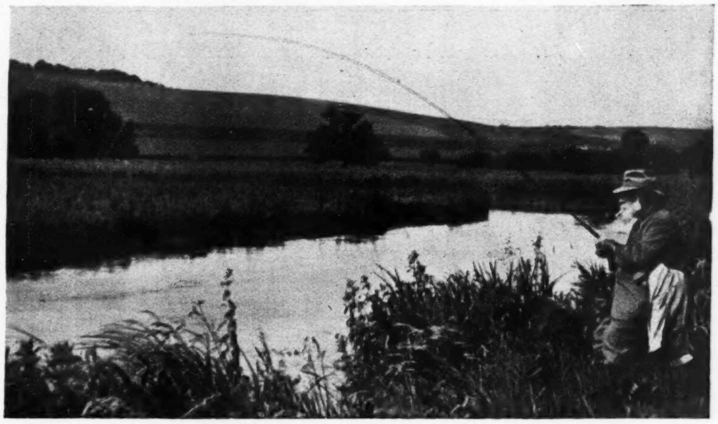
Infinite Variety.

There are few who realize the wealth of subjects by the side of an English stream. By way of illustration, I may say that I have fished the same two or three miles of a chalk stream for the last five years, and have exposed at least a couple of gross of plates.

To many the changing of plates is irksome, but with a modicum of practice even a dozen plates can be taken out of the slides, packed face-to-face, and replaced in their original wrappings, in total darkness, very quickly. I always put a piece of innocuous paper between the sensitive surfaces to prevent scratching.

The development, after the visit is over, can, with a little system, be carried out in a short time. Personally I develop one or two plates separately for

test, and then do the remainder in bulk. A whole-plate dish will comfortably carry a dozen vest-pocket size plates, and from the data obtained from the tests, these are either developed by time, or in a bright yellow light after desensitizing. I am told by the trade developing firms that if a dozen small plates are dealt with at a time it is advisable to pass a soft brush over them in the developer to prevent air belts being troublesome.



H. S. HALL,
angler, inventor of the eyed fly, and even better know for his classic "Algebra."

Perhaps there is a knack in pouring the solution on which I have unconsciously acquired, as I never use a brush, nor do I have any trouble of this kind.

In these small sizes the best will require enlargement, and consequently the negatives should all be kept quite thin. Where contact prints are wanted it is a simple matter to choose a grade of paper to suit, and much easier than to develop for contact printing and have difficulty in enlarging those selected for the purpose.

Quartz Glass in Quantity.

ONE of the researchers in the Thomson Research Laboratory of the General Electric Company of the United States, Mr. E. R. Berry, has recently made a discovery which will profoundly affect the progress of science. He has discovered a method of fusing quartz in large quantities, so that the use of this mineral will no longer be confined to such apparatus as requires it only in small quantities. Fused quartz will soon be available for manufacturing the lenses of larger telescopes than any now in use. The limits of glass as the material for great telescopic lenses have been reached, and there is little hope of advancing much further in the manufacture of lenses of optical instruments with it.

But Mr. Berry's discovery opens up a field much wider than that of the microscopist or of the astronomer A mass of common glass one metre in thickness absorbs 65 per cent. of the light which passes through it, and even the same thickness of the finest optical glass absorbs 35 per cent. But this new fused quartz absorbs only 8 per cent. The rods or pencils of quartz not only permit the passage of light throughout their length—even if they be 16 feet long—without an appreciable loss; but, what is more curious, it is claimed that, if quartz rods be bent into curves or corkscrews, the light emerges at the far end and does not escape through the sides. Quartz transmits the ultra-violet rays and it will now become possible by employing quartz rods of various dimensions and shapes to apply the ultra-violet ray treatment to many parts of the body that have hitherto proved inacessible.

Quartz is familiar enough in many ornamental and other stones. To mention but a few, agate, amethyst, jasper and flint are all species of quartz. It includes all the native forms of silica and, of course, silica plays a large part in the production of glass. Glass sand, which consists of small crystals of impure silica or quartz, is the basis of glass but to it are added compounds of potash, soda, lead, lime, zinc and aluminium, and the effect of these added chemicals reduces the temperature at which the quartz granules can be melted. But pure quartz or rock-crystal consists of 100 per cent. pure silica, and its high-fusing point (about 4000° F.) is associated with the absence of the chemical mentioned above. The raw material which Mr. Berry has been working with is the natural rock-crystals which is perfectly transparent. This is melted in an electric vacuum furnace, and the product, though resembling glass in appearance, is not ordinary glass but quartz-glass.

The work is a striking example—and there are many others—of the momentous discoveries that are made by the great scientific staffs of the more prosperous businesses in America, They keep a large number of highly trained experts whose sole duty is that of investigation and research.

Researches on the Laws and General Principles of Bird-Migration.

By C. J. Patten, M.A., M.D., Sc.D., F.R.A.I.

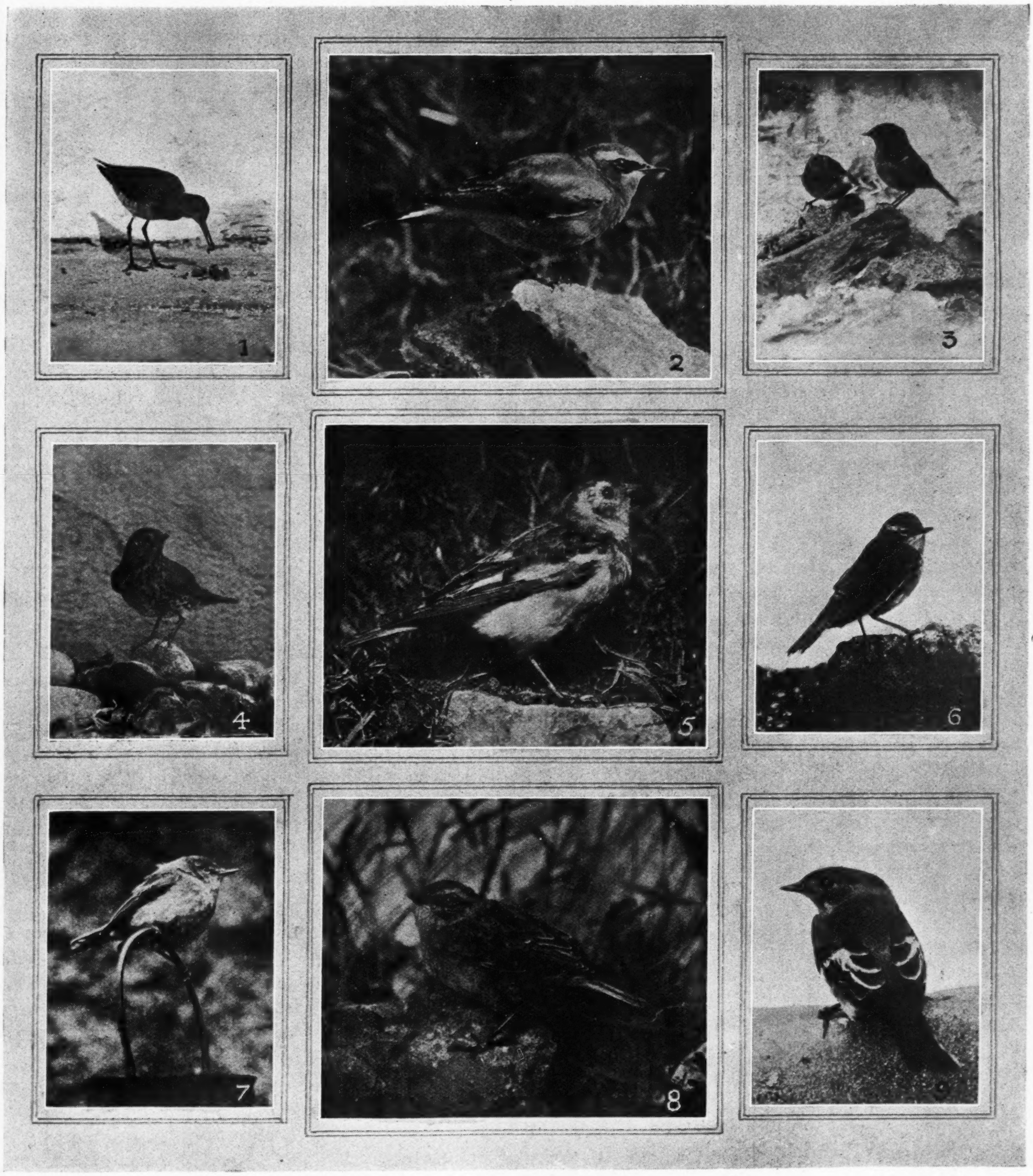
Professor of Anatomy, University of Sheffield; author of "The Aquatic Birds of Great Britain and Ireland," "Diurnal Migrations of the Tushar Rock," etc.

The migration of birds still holds unexplained mysteries. Little by little we are beginning to understand the laws which govern the movements of the different species. Much observation work still remains to be done.

During the spring and autumn migratory movements I have, for many years, resided at light-stations off the Irish coast, my visits on each occasion lasting several weeks on end. These excellent ornithological observatories are situated along and in many cases intersect the main fly-lines of hosts of travelling birds. In certain meteorological conditions the voyagers, decoyed by the brilliancy of the luminous beams of the lantern, are held up, thereby forming vast assemblages, while on the other hand in clear weather the rhythm and regularity of the diurnal movements can be observed with great advantage; in short, a unique opportunity is afforded one of obtaining first-hand information at light-stations on many aspects regarding the laws and principles of bird-migration. At the outset a word in passing in regard to the historical side will indicate and emphasize to what an extent our knowledge has advanced on the subject. Observations on the seasonal movements of birds have been recorded by naturalists and sung by the poets of old, centuries before the Christian era, and yet until comparatively recently migration was but dimly conceived and only by a small minority of observers. For many years past the generality of ornithologists refused to credit birds with that remarkable flight factor which we now know most species possess. Hence there arose primitively strange views regarding the seasonal disappearances and reappearances of birds. Belief in hibernation was popular and widespread. Birds betook themselves into nooks and crannies for their long winter sleep. Curiously enough, swallows, and other particularly swift and powerful birds on the wing, were prominent among the numbers. Stranger still was the idea that birds submerged themselves and sank to the bottom of pools where, becoming caked into lumps of mud, they remained torpid during the cold weather; another weird idea was that they were transmuted into species known to remain in our lands throughout the year. Myths are extremely tenacious, and only as far back as 150 years ago the myth of hibernation was more prevalent than the truth of migration. To-day we view the question in a very different light; we have indeed reversed our opinion, and whilst the notion of hibernation is not quite extinct, it is certainly obsolete to a marked degree. To-day, without fear of contradiction, we can state that migration is the *rule* among our British birds, only a small minority remaining stationary. What paths of research have we pursued to reward us with this important discovery? Firstly, a more exact study of the anatomical and physiological features of so highly a specialized creature as the bird reveals, among other things, that the muscular mechanism of the wings is so wonderfully developed among many carinate forms that astonishing endurance in flight is quite possible. Velocity in flight, which is no doubt very remarkable in some birds, and which no doubt is a great asset, is nevertheless a feature of less importance. Endurance permits of long steady pilgrimages being accomplished even among our frail and fairy forms.

Anatomical Theories.

We have proved by careful dissection and by deductive observation on the living bird, that the eye is the mainstay of its brain, the sheet-anchor of its life. There is reason to believe that this keen, highly perceptive, discriminating organ can minutely analyse the topography of the migration-routes, carrying away mental pictures in the higher visual centres of the brain which are accurately and tenaciously memorized. Anatomical and physiological research, more particularly of the respiratory apparatus, tell us further that birds fully appreciate variations in the weight and temperature of the atmosphere: these highly-sensitive feathered barometers ascend to higher altitudes, or skim over the earth's surface in order to avoid adverse currents, and they easily seek out and become cognisant with advantageous air-currents lying in their migration-routes, such for instance as trade-winds which blow in a constant direction. It has been suggested that there are definite highways in the air along which migrants are accustomed to travel. Personally I have repeatedly observed that the seaboard is largely availed of by the



1. REDSHANK FEEDING. 2. GREENLAND WHEATEAR. 3. PAIR OF GOLDCRESTS.
4. SONG THRUSH. 5. SNOW BUNTING. 6. SEDGE WARBLER.
7. CHIFF-CHAFF. 8. WHIN CHAT. 9. PIED FLYCATCHER.

vanguard of voyagers, these hugging the coasts, pilot the laggards and overland travellers. The latter are kept in touch by the loud far-sounding call-notes of the leaders. Here again we learn by means of our anatomical studies what an adjunct is the highly developed vocal apparatus to the migrating bird.

It is only of late years that the marvels of flight in birds have been fully appreciated; the study has become very popular *pari passu* with the development of aeronautics. Birds often sail, glide, or plane, to conserve their energies on the wing. Their utmost velocity is not expended during their entire migratory movements; extra speed is reserved in case of contingency. Nowadays, those of us who have located ourselves at favourable observatories, notably at light-stations, and have sedulously attended to the subject, have no doubts whatsoever regarding the ability of birds of many forms to undertake long journeys. Viewing the matter popularly and in a light-hearted frame of mind, one would think that our feathered friends would be unenterprising not to avail themselves of their unsurpassed powers of locomotion for seeing the world!

But scientifically we must interpret the great principles of bird-migration otherwise. There is reason to believe that birds, as they arose from their reptilian-like ancestry, were for the most part limited in their wing-power. Indeed, it is surmised that the ostrich and other flightless forms are survivors of the ancestral avian types. Birds were therefore not in the first place endowed with powerful flight to enable them to trip hither and thither for mere amusement or change of scene! Migration is far from being the enviable gift of Nature oft sung by the poets: it is fraught with grave dangers; betimes the scene of tragedy with a heavy casualty list. Migration, like every other great biological activity, is the product of evolution.

Food Requirements.

In creatures such as birds, so brimming over with life and emotion, in whose bodies the fire of life glows so brightly that constant stoking of fuel behoves them to make an incessant search for food, and, as a consequence, to endow them with prodigiously large appetites, we can readily see how very keen must be the struggle for existence on their part. As birds continued to multiply and to spread themselves over the face of the globe, one can understand how the search for food would have become a serious problem; in our latitudes purely insectivorous birds, if they remained with us all the year round, would become starved-out in the winter. Land-birds of the high northern latitudes would in winter have to retreat before the widespreading mantles of snow, moreover they would experience great loss of daylight—two factors rendering the search for food wellnigh impossible.

Few of our familiar birds in secreting their nests in the spring and early summer when food may be plentiful close by, would find in such areas an adequate supply of food all the year round. Conversely, if they selected as breeding-grounds such areas where food was plentiful at all times of the year, it would be more than likely that these same areas might prove highly detrimental to the preservation of the species. To put it shortly, birds of many kinds would be forced to move to and fro between their breeding and feeding grounds. When these movements became rhythmic and hereditary they would typify migration.

In the dim past ages it is likely that many migrations were for the most part local in character, similar to what we find in the case of some of our curlews and golden plovers, which move up from their feeding-grounds on the mud-flats in winter to their breeding-grounds on the moors in summer.

The Time-table.

Geological and climatic changes, extending over a vastly lengthened period of time, might ultimately cause divergence of the two areas—breeding and feeding—to such an extent that an original incipient movement might be evolved into a migration covering hundreds of miles. We are now in a position to formulate and say that the initiative factors subserving bird-migration are feeding and breeding. We next ask, What are the immediate stimuli which cause birds to migrate? In other words, What pulls the trigger? Do migratory birds always wait until the supply of food at their breeding-haunts has become exhausted? Conversely, do they return to their breeding-grounds with marked regularity and punctuality? In answer to the first question it is observable in many cases that birds leave their breeding-areas directly the young can look after themselves—indeed, in exceptional cases when the young are at too tender an age to cater for themselves; in either case when food is still abundant. So ingrained and active has the migratory impulse become in the parent birds that, directly the breeding duties are completed, they are anxious to be off, leaving their broods to seek out what food may be obtainable in the district of their nativity. The return journey to the breeding-grounds is effected punctually and with feverish haste. Food is abundant as a rule at the point of embarkation, but often scant when the traveller first reaches the

projected destination. The strong incentive to migrate in spring is no doubt correlated with the rapid development of the reproductive organs thereby stimulating the procreative feelings. The mental excitement to reach the scenes of accustomed courtships and wedlock must prove an overpowering stimulus to get under way. In all movements, however, when once the migration season has been properly reached, weather influences afford the immediate stimuli. A sudden fall in temperature sends hosts of migrants on their southern journey; a sharp rise in temperature drives the voyagers northwards. In either phase of migration it is to be noted that calm settled weather, with high barometric pressure, and gentle gradients, greatly enhances the exodus.

Laws of Migration.

In our isles the regular migrants are classified as inter-British, summer visitors, winter visitors, and birds of passage. Although the extent of the journeys undertaken, and consequently the geographical distribution, varies to a great extent in not only different classes but even in the same species, nevertheless the various phases of migration are governed by a law which formulates that all birds breeding in our hemisphere seek out the northern limits and return to winter in the southern limits of their migrations. For example, great numbers of song-thrushes, blackbirds, starlings, larks, and other familiar birds which breed in Scandinavia, move southwards to the British Isles in winter, while many of those which breed in our isles spend their winter in more southern climes. It is obvious then that such species may represent both winter and summer visitors to our isles. But so variable is the geographical distribution of these birds that we find many, in each particular species, migrating only within the confines of the British Isles, while in lesser numbers they may remain stationary as residents throughout the year.

The birds of passage which rush past our isles may be compared to a long-distance non-stop express train; their movements, however, indicate the same purpose and are subject to the same law as already indicated in the case of summer and winter visitors. Thus we find some blackbirds, thrushes, and others already mentioned, flying north to breed in Scandinavia and south to winter in Spain. Such birds have the most extensive geographical distribution of the series with which we have been dealing. It may be formulated as a fundamental principle of bird-migration that the farther a bird breeds north the farther south it winters within the limits of its geographical distribution. Some shore and sea birds migrate almost from Pole to Pole. We have another phase of migration which may be classed as irregular, but it frequently takes place in winter. Here we finds birds which, on leaving their breeding-quarters in northern Europe, had intended to spend the winter in central Europe, but owing to an unusually cold change of weather they were obliged to take a second journey. This route is generally directed from east to west, the destination aimed at being the south-western seaboards of Great Britain and Ireland, where it would appear that the influence of the Gulf Stream renders the climate much milder. Lastly may be mentioned the curious spasmodic irruptions of certain birds at irregular intervals. The visitors often arrive in flocks and their sudden appearances are difficult to explain. Many of us are familiar with the irregular visitations which we have received from time to time of sand grouse, waxwings, and cross bills.

Our beautiful and dainty little warblers, sweetest minstrels of the feathered world, visit and breed in our isles in summer when various forms of gnats, flies, and other winged insects, which form their staple diet, abound. These birds leave us in the autumn to spend the winter in Afric's sunny climes, some of the frail little travellers crossing considerably beyond the equatorial line. As they, with the swallows, cuckoos and corn-crakes, flit away in autumn, their places are taken by familiar birds such as blackbirds, thrushes, and others before mentioned. These, coming from more northern latitudes, can sustain themselves on worms, grubs, snails, wild berries, seeds, and other vegetable matter during the winter. In winter various classes of birds visit the British Isles and countries farther south whose breeding-range is restricted to areas in northern and arctic Europe. Fieldfares, redwings, (both thrushes), bramble-finches, and snow-buntings, and a great variety of water-fowl are included in this category of our purely winter visitors.

Globe Flyers.

The journeys undertaken by some birds are really marvellous. The tiny goldcrest—the smallest European bird—weighing but a dram, and some other avian liliputians, cross the waters of the North Sea on dark November nights, while some species of sandpipers migrate from islands well within the Arctic Circle to New Zealand and Cape Horn. These wonderful aerial feats are undertaken by birds barely three months old! The Arctic tern (a common sea swallow) flies almost from Pole to Pole twice a year.

It may be said of a truth that no country is more favourably situated than ours for witnessing the movements of migratory birds. So central in position are the British Isles that they may be compared to a great junction, where travellers meet and change

their courses to reach their many and oft widespread destinations.

Birds of passage largely predominate along the British coastlands as they speed hither and thither from arctic Europe to the southern hemisphere.

On the Lighthouse.

In conclusion I may mention how weirdly attractive and novel is the spectacle which presents itself to the student of ornithology as in his silent night patrol he watches from the dizzy heights of the lighthouse balcony the behaviour of bewildered migrants as they reel and topple under the mesmeric influence of the luminous beams. The intensity of the rays of the lantern not only effaces the plumage patterns, but birds, whether dark or fair plumed, appear white or red according to the colour of the ray traversed, while the fluttering of wings conveys to the observer the impression that careering round the lantern are hundreds of gigantic scintillating precious gems. Standing on the balcony on a migration night, amid an assemblage of myriads of migrants, I have found my own person utilized for perching purposes to such an extent that I veritably became decorated with birds.

I vividly call to mind a pitch-dark, calm, misty night when the rays of the lantern were unusually brilliant. On that occasion a little willow-warbler alighted on the top edge of my ear; on my right shoulder sat several swallows contentedly in line as they may be observed to do on telegraph wires; on my other shoulder two thrushes and a blackbird jostled each other for perching space; a tiny goldcrest alighted on the button of my coat; finally a starling, in a paroxysm of fear, sought cover by scrambling up my leg and then clinging to the rim of my waistcoat pocket. On that memorable night hundreds of birds, dazzled to a degree and unable to stay their flight, dashed headlong against the lantern and were killed outright. It is cheerful, however, to remember that though the casualties appeared heavy they were, proportionately, but as a drop in the ocean, so prodigious were the numbers of nocturnal visitors which managed to pass the danger-zone unscathed.

[In contributing these pages to *Discovery* I desire to take the opportunity of expressing my grateful thanks to the Royal Society for awards of substantial Government grants to aid in my researches, and also to the Commissioners of Irish Lights for their kind permission to reside at light-stations off the Irish Coast.]

IMPROVING ALUMINIUM ALLOY CASTINGS.

In a paper on "A Method of Improving the Properties of Aluminium Alloy Castings," presented at the annual general meeting of the Institute of Metals by S. L. Archbutt, F.I.C., new casting methods for aluminium were suggested.

The experiments described in this paper and the results obtained from them are to be regarded as indicating the possibilities of a method of treating aluminium and certain of its alloys, which serves to eliminate at all events a considerable proportion of dissolved gas and thus reduces unsoundness, and to a considerable extent removes pin-holing. The process suggested consists in allowing the molten alloy or metal to cool slowly in the crucible in the furnace until it has just completely solidified; it is then remelted, and may be carefully stirred, raised to the pouring temperature, and cast. Ingotting the metal is not satisfactory, as the ingots cool too quickly, and during remelting are too much exposed to the furnace gases.

In a later experiment described, passage of an inert gas through the melt during slow cooling and solidification has been found to improve still further the soundness of resulting sand-cast bars.

Slightly anomalous results have been obtained in some cases, and it is not yet clear how far the method is of value in other alloys, whether consisting mainly of aluminium or of other metals. It is evident that much further investigation is required. Meanwhile, the author has learnt that simultaneously and independently Professor C. A. Edwards and Mr. W. E. Prytherch of Swansea, working on the effect of gases in copper (for the British Non-Ferrous Metals Research Association) have discovered a similar effect obtained by solidification in the crucible in the case of pure copper.

DENSITY OF RHODIUM.

Sir Thomas Kirke Rose, D.Sc., A.R.S.M., Vice-President of the Institute of Metals, read a short paper on the density of Rhodium at the annual general meeting of the institute.

Two specimens of Rhodium were kindly prepared by Messrs. Johnson & Matthey for the purposes of the investigation, one being forged up from sponge and annealed but not melted, and the other melted from sponge in the oxyhydrogen blowpipe and forged while hot. The Rhodium sponge was chemically pure.

The density of the melted specimen was found to be 12.47 in vacuo at $0°/4°$, but the other specimen was evidently not free from internal cavities as its density was only 12.22.

Previous determinations by other observers had given 12.1 to 12.6, but were unsatisfactory owing to various causes.

Benzene, 1825-1925.

By A. T. de Mouilpied, M.Sc., Ph.D., F.I.C.

The synthetic manufacture of dyestuffs and many other important chemicals which are the basis of vast national industries to-day have all sprung from Faraday's discovery of benzene a hundred years ago.

On 16th June, 1825, Michael Faraday, then an assistant at the Royal Institution, read before the Royal Society a paper entitled "New Compounds of Carbon and Hydrogen." One of these he called "Bicarburet of hydrogen," as he established its empirical formula to be C_2H, the atomic weight of carbon being taken as 6. This compound, isolated and identified for the first time, has proved of outstanding importance in the development of chemical theory and in the establishment of some fundamental industries based on research, and brought into being by the brilliant achievements of synthetic organic chemistry.

The bicarburet of hydrogen is no other than the benzene of the chemist, the benzol of the industrialist and the motorist.

Faraday's Start.

The story of the rise and development of the synthetic dyestuff industry has often been related; less often has been told the story of the laying of the foundation stone. The passing of a century gives us the opportunity of re-examining the facts, the chance of recapturing something of the freshness, of the eagerness of those early days of discovery and the privilege of again paying tribute to the genius of a great pioneer, and to the modesty and charm of a great character. Faraday, the son of a blacksmith, was at twelve years of age earning his living by delivering newspapers and was learning the craft of bookbinding. In his leisure hours he read the books he was binding, and from an article in the "Encyclopædia Britannica" he obtained his first ideas of electricity, and from Mrs. Marcett's "Conversations in Chemistry" what he described later as "an anchor in chemical knowledge."

Sir Humphry Davy was then at the height of his fame as discoverer and lecturer, and the Royal Institution in Albemarle Street a fashionable resort. Faraday attended Davy's lectures, took notes which he subsequently elaborated and illustrated and sent to Davy with a request that he would help him to escape from trade and enter the service of science. In March, 1813, Faraday, then twenty-two years old, was appointed assistant to Davy at a salary of 25*s*. a week with the use of two rooms.

It is interesting to remember that Faraday, immortal in the annals of science for his discoveries in physics, did his first work in chemistry. He ever disliked the term "physicist" and to the last described himself as a natural philosopher. Both in name and in practice he was able to serve two branches of science.

He published his first paper in 1816, in the quarterly *Journal of Science*, giving the results of his analysis of a caustic lime from Tuscany. He then turned his attention to the condensation of gases and, following a suggestion of Davy's, liquefied chlorine. His interest in this work may very well have led to the discovery whose centenary celebration falls this year, for it was in the condensation products obtained in the process of converting oil into illuminating gas that benzene was found. There were at that time two competing methods for the lighting of houses. Coal gas, first used in 1792 by William Murdoch for the lighting of his own house at Redruth, had been somewhat slow of acceptance. Even before its introduction it had been found that oil such as cod-oil could be decomposed at about 1000°C. to yield gas of high illuminating power. It was a process comparable with to-day's "cracking" of petroleum oils, the aim, however, being to obtain gaseous rather than liquid products. A patent was granted in 1819 to Gordon & Head for compressing oil gas, a pressure of thirty atmospheres being used, and it was Mr. Gordon who furnished Faraday with a quantity of the fluid obtained during compression. The Portable Gas Company supplied the compressed gas to houses, and liquid was found in these vessels as well as in the receiver from which they were filled. Faraday's attention had been drawn to oil gas as early as 1820, and he states that 1,000 cubic feet of good gas yielded almost a gallon of liquid. This was a thin light fluid, transparent and colourless, with a specific gravity of 0.821.

Identity of the Fluid.

By repeated distillations, Faraday obtained two new compounds, one of which we know now as butylene, and the other was benzene. The boiling point of the latter was given as 85.5°C. "in contact with glass."

It is very interesting to find that John Dalton had already examined oil gas, and Dr. Henry reported in 1821 that it contained not only "olefiant gas" (ethylene), but another similar gas requiring much more oxygen for its combustion but having the same

property of uniting with chlorine. It was Faraday who proved that these two gases were composed of the same elements in the same proportions, but that one had twice the specific gravity of the other. The gases were, in fact, ethylene C_2H_4 and butylene C_4H_8. The establishment for the first time of this kind of relationship was of the utmost importance in its bearing on Dalton's atomic theory and in leading to the conception of isomerism formulated by Berezelius in 1833.

A False Conclusion.

There can be but little doubt that the variations in Dalton and Henry's results were due to the unsuspected presence of benzene in the gases they examined.

Faraday also obtained benzene from the liquid which had condensed in the pipes leading to an oil-gas gasometer, and he separated it out by freezing. He extended his observations to coal-gas tar, but says, "as was expected, no bicarburet of hydrogen could be detected in it." C. B. Mansfield, who years later carried out the classical piece of work on the isolation of benzene from coal-tar, was prompted by an admirable and characteristic sense of loyalty and fairness to offer an explanation. He pointed out that some samples of coal-tar contain very small proportions of the more volatile liquids, and goes on to say, "so that the unfortunate escape of this substance from the acumen which then threatened its detection was probably owing to the inquiry having fallen upon unfavourable specimens."

What followed must be dealt with more briefly. In 1834 Mitscherlich obtained benzene by heating benzoic acid with lime. It was he who suggested the name "benzin," since the acid from which he obtained it was a constituent of a resin obtained from styrax benzoin, a tree growing in Sumatra. Liebig did not approve of the name and, as editor of the *Annalen*, changed it to benzol, while indicating his preference for Faraday's original name. In the same year Mitscherlich discovered nitrobenzene.

It was not until 1845 that the presence of benzene in coal-tar was clearly demonstrated, and this was done by Hofmann, who converted the benzene into nitrobenzene and this by reduction into aniline, for which a delicate test was known. Hofmann did not, however, isolate the benzene itself. In the meantime, aniline had been discovered. In 1826, Unverdorben obtained from the distillation of indigo a substance he named 'krystallin.

Runge, in 1834, obtained in coal-tar a substance which he called "kyanol." Fritsche in 1840 distilled indigo with caustic potash and isolated a product which he named "anil," from the Portuguese for indigo. Finally, the Russian chemist, Zinin, in 1840 reduced nitrobenzene and obtained "benzidam." It was Hofmann who in 1843 proved that these four products were identical, and who established for this substance the name "aniline."

In 1849 C. B. Mansfield published a paper entitled "Researches on Coal-Tar, Part I," which detailed work undertaken at Hofmann's request. This paper is a very remarkable one, remarkable for its modesty, for its power of sustained effort through a laborious and tedious series of experiments, for its results, and —not least—for its foresight. Mansfield applied to coal-oil the method Faraday had used for the dissection of gas-oil. By repeated fractional distillations Mansfield obtained a series of products, and from the fraction boiling between 80° and 85°C. he isolated benzene. It boiled constantly at 80°C. and left no residue and, in his own words, "it is a pure substance." Suffice it is to say that in all essentials Mansfield's method holds good to this day. Part II was never published, for in 1855 Mansfield met his death through the boiling over of a benzene still.

Mansfield noted many of the physical and chemical properties of benzene and its use as a solvent, and says prophetically, "The promises which benzole makes of utility are sufficiently numerous to encourage a belief that it may form a special object of manufacture and commerce. It may be procured to any extent from coal-tar in which it has hitherto been wasting its sweetness in the desert air."

Benzene, nitrobenzene, aniline, were now all known, methods of preparation established, and the stage set for the crowning of Faraday's original discovery, by a discovery responsible for a greater expansion of organic chemistry than any other.

The First Dye.

In 1856, W. H. Perkin, also a student of Hofmann, obtained, by the oxidation of aniline, the first artificial dye, mauve. Looking back on the extraordinary growth of the synthetic dyestuff industry, on the new fields of discovery and invention which were opened up, on the progress made in understanding chemical phenomena, on the results achieved bearing on the welfare of the state and on the health and joy of mankind, Perkin's discovery is seen to be one of the mountain peaks in the chain of scientific discovery.

Faraday laid the foundation stone, Mansfield provided the means and Perkin the wonderful stimulus of a discovery, which together have resulted in one of the miracles of human achievement.

Animal Electricity.

By Professor Fraser Harris, M.D., D.Sc.

All living things generate a certain amount of electricity. This phenomenon is made use of in the diagnosis of certain heart troubles.

MANIFESTATIONS of electricity seem to be associated with almost every kind of activity in the universe. In the world of the non-living, friction, the evaporation of water, the transference of heat, the passage of liquids through membranes, chemical activity and magnetism are all accompanied by the production of electricity. It would be difficult to name any physical process in which electricity does not participate directly or indirectly.

The living body and its tissues are no exception to this universal happening.

Let us first consider the muscle in the living body as regards its relations to energy. Since muscles are warm, they must be continually producing heat.

Minute Currents.

In fact, by far the greatest amount of heat set free in the body has had its origin in the muscles. Even when the muscles are what we call "at rest" they are still producing heat, though, of course, far less of it than when they are in action.

When muscles go into activity they evolve in addition to heat a certain amount of electric current. It is, as may be imagined, much more difficult to prove that muscles produce electricity than to show that they give rise to heat, for to demonstrate their electric currents we have to use a very delicate instrument, far more complicated than the thermometer, called the galvanometer.

Tested by the galvanometer it is found that muscles give rise to no electric disturbance so long as they are at rest, but the moment they go into activity (contract) they are responsible for a current which at once makes itself evident in the galvanometer. These currents are of very low voltage, but they continue to run as long as the muscle is in activity.

Now the heart is a muscle—a hollow, complicated muscle—and each time it beats (contracts) it gives rise to a feeble electric current which is well demonstrated by means of a mirror galvanometer in a dark room. This instrument was invented by Lord Kelvin to indicate the presence of electric currents in submarine cables, but it has been found well-adapted to display currents of animal electricity. In this instrument a spot of light reflected from the mirror moves to the right hand or to the left on a white wall every time a current passes round the galvanometer.

Now since the heart is an automatically beating organ, and can continue to beat for many hours after it has been removed from a cold-blooded animal, so the electric currents to which it gives rise will continue to swing the mirror as long as the heart itself survives. Indeed, the mirror continues to swing for some hours after all visible signs of life have left the heart. It is an impressive sight: in the stillness of the dark room the spot of light maintains its silent oscillations at the exact rhythm of the beating of the tiny living heart of the long-dead frog.

The beating heart of the embryo chick in the egg, when only just formed, can produce sufficient electric disturbance to influence the galvanometer.

If we bring the heart to a standstill without killing it, by the application of some appropriate drug, then no electricity is manifested until the beating is resumed.

The latest development in the study of animal electricity is to photograph the currents of the beating human heart. This is done to-day by means of a very delicate and costly apparatus called the "string" galvanometer.

Fig. 1 shows the original method in which the oscillations of mercury in the capillary electrometer were photographed. Fig. 2 shows the record (electro-cardiogram).

Clinical medicine has thus been provided with a new method of diagnosis in heart disease, for the form of the record becomes distinctly altered in abnormal conditions of that organ.

Electricity in the Eye.

One of the most interesting demonstrations of electricity of animal origin can be made with the retina of the living eye. Having killed a frog, we remove an eye and place it in connexion with the galvanometer in the dark room. The excised eye will live quite long enough to show a current when a lighted taper is held for an instant opposite the pupil. The retina in the depths of the eye responds to the stimulus of light by producing an electric current, and curiously enough yields an increase of current when the light is withdrawn.

All living tissues respond to stimulation by evolving electricity. For instance, when a nerve conducts its impulses, the only observable phenomenon is

a series of electric currents in it. When a gland secretes, when a muscle twitches, when the heart beats, when the eye sees, electricity is always produced. As might be supposed, the absolute intensity of these currents is very small, of the order only of 0.01 volt. The late Dr. Waller showed that so relatively inactive a tissue as the crystalline lens of the eye could nevertheless produce an electric current if the stimulus (an electric one) was sufficiently energetic.

There *is* such a thing then as animal electricity; but this electricity of animal origin is a physiological fact that has been overlaid by more nonsense, probably, than any other. The fantastic absurdity called "electro-biology" was much heard of fifty or sixty years ago.

Galvanic Effects.

Animal tissues produce no "magnetism," as the physicists understand that term. The supposed power of magnets to induce the hypnotic state was long ago shown to be possessed by all sorts of agents that have nothing whatever magnetic about them.

All living things, vegetable as well as animal, can produce electricity—leaves, flowers, fruits—all, if stimulated, can give rise to a current. It has actually been proved that young unripe apples give a better response than old ripe ones.

The man who discovered animal electricity was an Italian, Luigi Galvani, Professor of Anatomy in the University of Bologna. He discovered it accidentally. Galvani noticed that when the living hind legs of a dead frog, which were hanging over a copper hook laid on an iron railing, came in contact with the iron the leg muscles twitched. Galvani at once concluded that these convulsions of the legs were somehow an expression of animal electricity, but Alessandro Volta, his brother Professor in the University of Pavia, proved that, in the experiment just quoted, there is indeed electricity developed—not, however, by the living tissues, but at the contact of the two dissimilar metals, the copper hook and the iron railing. When the toes, blown against one of the uprights of the railing, completed the circuit through the legs their muscles twitched.

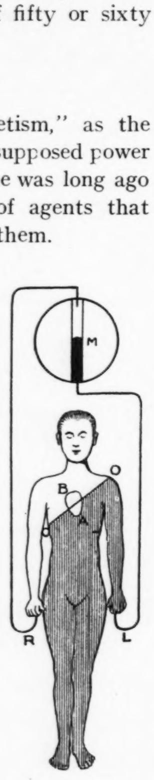


FIG 1.—DIAGRAM OF THE CAPILLARY ELECTROMETER for photographing the currents of the human heart.

B. Base; A, apex; OO, electrical equator; M, mercury whose oscillations are photographed; R and L, hands holding the electrodes.

Galvani nevertheless persevered in his efforts to demonstrate the reality of electricity of animal origin, and succeeded in devising a number of convincing experiments known as "contractions without metals." Quite the most striking of these is to allow the nerve supplying a muscle to lie over the isolated beating heart. At each beat of the heart, the current produced by the heart stimulates the nerve which in its turn causes the muscle to twitch; it is a very curious sight to see the leg of a frog jerking at the exact rhythm of its own heart.

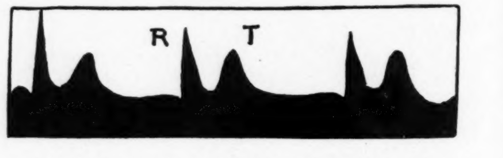


FIG. 2.—ELECTRO-CARDIOGRAM OF HUMAN HEART.
The two well-marked waves, R and T, are due to the activity of muscle in the ventricle.

Curiously enough, it is in the group of the fishes that we find the most spectacular production of electricity. One of these, an eel-like creature, a native of certain warm South American rivers, can give a shock whose intensity is at least 400 volts. A specimen of one of these fishes has recently been placed in the new aquarium at the Zoological Gardens, London. These electric eels are a family (Torpedo) by themselves which have developed this curious power as a means of protection from their enemies, or for the purpose of killing their prey.

It is quite clear that in the electric fishes certain muscles have been profoundly altered so that, instead of producing movement and heat as ordinary muscles do, they manufacture electricity but at an intensity vastly greater than does any other living tissue.

Now just as ordinary muscle depends for its activity on impulses reaching it by means of motor nerves from nerve centres, so too the electric organ is under the command of the cells of a nerve centre. In fact, the nerve-cell in the spinal cord which fires off the electric battery of one side is by far the largest nerve-cell known. Each of these cells has one huge outgrowth of fibre which, proceeding down towards the battery, breaks up into a large number of small fibres for the various plates or discs of the electric organ.

The fish can discharge its salvos very much after the manner of a battleship discharging hers. The fish always discharges the shocks when it is handled or frightened, but it can also produce them by voluntary effort. The discharge is not of the nature of a constant current, it is rather that of a series of recurring shocks. By means of suitable apparatus, the currents can be made to ring a bell or cause a lamp to glow.

The Enigma of the Origin of the Maya Culture.

By Edward C. Rashleigh.

Archaeologists hold widely-opposed theories concerning the origin of Central American culture, some holding that it was of Asiatic origin, some a spontaneous local development. The author reviews both sides.

NOT long ago Doctor Thomas Gann announced that Doctor H. J. Spinden of Harvard had discovered definite proofs of the exact year from which the ancient Maya builders of Central America dated their time-count, namely 3373 B.C., and that, consequently, it will now be possible to align precisely their calendar with our own, and so to fix beyond dispute, through their dated monuments, the age of the numerous ruined cities which lie scattered in the tropical forests of Guatemala, Honduras and Yucatan—will go far, if the proofs be substantiated, to settle a long-standing controversy between two opposing schools of archaeologists.

There are those, on the one hand, such as Professor S. G. Morley, Drs. Spinden and Tozzer, and Mr. C. P. Bowditch and others—whose long and extensive work in the actual field entitles their conclusions to the greatest weight—who insist that the Maya culture is the peculiar growth of American soil and environment, uninfluenced, except possibly in its most remote beginnings, by any contact with the Old World. And there are others, again, notably Professor Elliot Smith and his following, who maintain—and with no uncertain voice—that the inspiration of the Maya civilization came from without, and had its definite sources in Cambodia. Their contention indeed, may be described as a corollary to Professor Elliot Smith's well-known theory that "Egypt originated the germs of the civilization of the whole world," and that these germs were ultimately and by slow degrees diffused via Southern India and Indo-China to Eastern Asia and Melanesia and thence by Polynesian sailors "to the far-flung isles of the Pacific Ocean and to Central America."

Complex Calendar.

To explain the significance of Doctor Spinden's discovery it will not be necessary here to describe the Maya calendar in detail.

It will be as well, however, to state briefly what their numerical system was. Except for one modification, this system was vigesimal, and the unit of reckoning was the single day, for which the native term was "kin," meaning "sun." Thus:—

20 Kins	(or days)	=	1 Uinal
18 Uinals	(360 days)	=	1 Tun
20 Tuns	(7,200 days)	=	1 Katun
20 Katuns	(144,000 days)	=	1 Cycle

A cycle, therefore, for which the native term is not known, was equivalent to about 395 of our years.

Now nearly all the monuments so far discovered in the archaic ruined cities bear calendrical inscriptions which commence with an initial date, and in many cases it has been ascertained that this initial date marks the time at which the particular monument was erected.

Unknown Starting Date.

It has further been found that all these initial dates are calculated from a certain fixed date in the remote past in the same way that we reckon from the birth of Christ. Thus, according to Professor Morley, to take an example at random, the initial date of a certain stela at Copan, usually known to students as stela B, reads—9 cycles, 15 katuns, 0 tuns, 0 uinals, 0 kins—usually written for brevity, 9.15.0.0.0—followed by the distinguishing day and month signs with their respective numbers, in this case, 4 ahau, 13 yax. This, therefore, signifies that the stela in question was erected $9 \times 144{,}000$ plus $15 \times 7{,}200$ days, or some 3,846 years, after that remote basic starting-point. Another stela at Copan known as stela P, to take another example, bears the initial date of 9 cycles, 9 katuns, 10 tuns, 0 uinals, 0 kins (9.9.10.0.0) which, by a simple sum in subtraction, is therefore seen to be earlier than that of stela B by 108 years. It is thus obviously possible, providing of course the dates are legible, to compare the ages of the various monuments on any particular site, and those of one site with those of another.

The vast majority of the archaic monuments so far discovered are dated within the 10th cycle. A few, however, occur in the latter half of the preceding cycle, the ninth, notably at Uaxactun, where a date has been found which reads 8.14.10.0.0, and there are others, again, which occur early in the eleventh cycle—e.g., a date reading 10.2.0.0.0 has been found at Tikal.

But though it has long been possible to compare the ages of the respective monuments in this way, the difficulty of correlating precisely the Maya dates with those of our own calendar has been another story. The two chief attempts that have been made to do so are those of Mr. C. P. Bowditch and Professor Morley. They have both been largely based on certain

native books known as the books of Chilan Balam, written from memory by native scribes after the Conquest, and containing the history and wanderings of a certain clan of Yucatec Maya set down katun by katun. The several versions of these books, however, though in general agreement otherwise, differ widely as regards the time-count; so that hitherto any attempt at an absolute alignment of Maya chronology with our own has been merely tentative and provisional. Mr. Bowditch, for instance, would make the date 9.0.0.0.0 equivalent to 94 B.C., while Professor Morley, whose dating is consistently later by 270 years, would make it equal to A.D. 176.

A SCULPTURED LINTEL FROM THE RUINED SITE OF MENCHÉ (OR YÁXCHILAN), CHIAPAS,
in which a woman of rank presents a tiger's head, prepared as a helmet, to the sacrificial priest.
(" Memoirs Peabody Museum," Vol. II, Part II, Plate 58.)

Doubts.

The importance, therefore, of Doctor Spinden's discovery, if accepted by the scientific world, is that there will now be an end of discrepancies, and the Maya time-count can henceforth be correlated exactly with our own calendar. The date 9.0.0.0.0 would now be equivalent to A.D. 178 and the period of the florescence of the archaic Maya culture, reckoning from the early date at Uaxactun to the late date at Tikal, would extend from about A.D. 70 to A.D. 612.*

How then does this new correlation affect the contention of Professor Elliot Smith who, in his recent book "Elephants and Ethnologists," asserts—"all the evidence afforded by the comparative study of the Maya civilization of America points clearly and definitely to Indo-China as the chief source of its inspiration," and again, "the American culture was actually derived in large measure from Indo-China"?

If the Maya culture was in full swing as early as A.D. 70, how could it possibly have been inspired by the Cambodian, which was centuries later?

The main basis on which Professor Elliot Smith founds his assertion—I use the word advisedly as he everywhere puts it forward as a dogmatic assertion rather than as a possible theory—is stela B at Copan, the date of which, by the way, in the light of Doctor Spinden's discovery, would now be equivalent to about A.D. 474. On each side of the top of this stela is a sculpture which contains a feature somewhat resembling an elephant's trunk, an animal unknown, of course, on the American continent. There are no tusks, nor can the sculpture as a whole be said in the least to represent an elephant's head. On the top of the supposed forehead of the supposed elephant there rests a bodiless turbaned head which the Professor describes as "an unmistakable Indian Mahout." After adverting to the prevalence of elephant symbolism in Cambodia and to Chinese references to that country in which special reference is made to model elephants carved in sandal-wood, he puts forward the suggestion that "such trinkets carried by seamen might have provided the model which enabled the Copan sculptor to reproduce the elephant's profile *with such remarkable accuracy.*" The italics are our own.

The Trunk Mystery.

The "elephant" controversy, indeed, is by no means new, not only as regards this particular stela, but as regards also certain conventional masks with curiously long snouts which have been found on the later Yucatec buildings, notably at Uxmal. Some have seen resemblances in these sculptures to the tapir and others

* The new correlation of Dr. Spinden agrees fairly closely with that already provisionally adopted by Professor Morley. It should be pointed out, however, that so eminent an authority as Mr. T. A. Joyce, as well as Mr. R. C. E. Long and others, have hitherto preferred the dating of Mr. Bowditch, which is the one used as regards the collection of the Mandalay exhibits in the British Museum. If Mr. Bowditch's correlation is correct the period of the florescence of the archaic Maya culture would extend from about 200 B.C. to A.D. 342, thus further invalidating the arguments of those who would claim a Cambodian origin for it.

again to the tortoise. The most authoritative theory, hitherto, as regards this particular stela has been that the supposed trunk is really the beak of the blue macaw. A new and different interpretation however, has quite lately been advanced which I venture to think is the true one. I allude to the recent exposition on the subject by the well-known naturalist, Doctor Henry O. Forbes, in *Nature* of 2nd August, in which he suggests that the so-called "elephant trunk" is "a feature derived from one or the other of the cephalopoda—squid, loligo, argonaut, octopus, or a combination of them," all of which, as he further points out, "are denizens of the eastern or western coasts of America." As he also notes, as regards the supposed Mahout, Mr. Maudslay's diagrams of this part of the stela, on which Professor Elliot Smith bases his argument, are misleading as they do not quite faithfully reproduce the original sculpture. The figure, as has been said, is merely a turbaned head poised on the mollusc's body and the bent arm and braceleted wrist which Professor Elliot Smith supposes to be grasping a "driving-stick" are purely imaginary, the "driving-stick" itself being in reality one of the animal's tentacles.

So much for the imaginary "elephant's head" and the equally imaginary "Mahout" on which the professor so emphatically relies as a proof of Indo-Chinese inspiration for the Copan sculptor.

Cambodian and Javanese origins for the Maya culture have previously been asserted with quite aggressive cock-sureness in a book published in 1909 and entitled "The American Egypt," by Messrs. Channing Arnold and F. J. Tabor Frost, from which, be it noted, Professor Elliot Smith quotes in his "Elephants and Ethnologists."

Older Theories.

According to these authors, those who claim the Maya culture to be indigenous have "not a leg to stand on"! Copan and Quirigua, it appears, were built by Buddhist architects who landed from Indo-China and Java some time in the eighth century! The "Great Temple" at Palenque, again, according to a writer in the *Edinburgh Review* of April, 1867, whom the authors quote with approval, "closely corresponds in its principal details" with that of Boro Budur in Java! On which they naively remark—"It may very well be that some of the very men who had assisted in the earlier building operations of Boro Budur were the architects of the building at Palenque"! Boro Budur, of course, was not commenced until about A.D. 850, and bears not the slightest resemblance whatever to any Maya temple, either at Palenque or anywhere else.

DESCENDANTS OF THE ANCIENT MAYAS—A LACANTUN INDIAN FAMILY.
("Memoirs Peabody Museum," Vol. II, Part I, Plate 6.)

But the book teems with dogmatic statements which reveal in the writers an extraordinary ignorance of the subjects they profess to treat.

Jungle Effects.

In their endeavour, for instance, to maintain that the Maya were crude Indians whose architecture must have been derived from overseas—as, according to them, there was no other race on the American continent capable of its achievement—they dismiss the remarkable cliff-dwellings of the Rio Grande and San Juan Valleys in Arizona as "mere heaps of unmortared stones," and actually describe the whole of the far more wonderful remains in Peru as being of "a very crude type" and assert that they "probably date from the later years of the fifteenth century"!

As might be expected, those who try to maintain that the Maya civilization had an Indo-Chinese or Javanese origin have necessarily attempted to show that the ancient cities have a far later date than that which competent authority assigns to them. Messrs. Arnold and Frost, for instance, bring forward the old and fallacious argument that the destructive rains and dense forestal growth would forbid an antiquity reaching back more than about a thousand years before our own day. They forget that while the forest does to a certain extent destroy, in a far greater degree does it protect. Had these ruins lain throughout the centuries unprotected by the almost impenetrable foliage which the tropical forest affords, and that moreover perennially, they would no doubt to-day be mere crumbling heaps of stones. Professor F. W. Putman, the late curator of the Peabody Museum of Cambridge, Mass., in a letter to myself in 1911 wrote—"I agree with

you fully as to the stability of the ruins and the fallacy of their rapid decay owing to rains and forest growth. Probably many of the ruins have met with far greater destruction within the last fifty years owing to the vandalism of the lumber-men and gum collectors than in the preceding thousand years.'

Reasons Against.

Quite apart, however, from the question of whether Doctor Spinden's conclusions are accepted or not, there is one objection to the theory of any direct outside inspiration for the Maya culture—whether from Cambodia or anywhere else—which appears to me at once insuperable and so obvious that a child could grasp it. That is the absolutely distinct and peculiar character of the Maya calendrical system and the Maya hieroglyphics which is found nowhere else. If Maya culture was directly inspired from Cambodia, how is it that there is no trace whatever in that country of any kindred system of writing? The perfection of the Maya calendar and numerical system, not to mention that of their highly-developed script, implies a knowledge of astronomy to which they could only have attained by minute observations extending over a very great period of years. Even Messrs. Arnold and Frost presumably would scarcely have the audacity to suggest that the Indo-Chinese immigrants invented the system *pour passer le temps* during their voyage across the Pacific.

LACANTUN INDIAN CHIEF CARRYING BOW AND ARROWS.
(" Memoirs Peabody Museum," Vol. II, Part I, Plate 6.)

That there are certain superficial resemblances reminiscent of the East in some of the Maya sculptures may indeed be admitted. But analogies are very far from being identities. If any foreign immigration ever occurred at all, it is more likely to have done so in an epoch extraordinarily remote, and that, too, more probably from the East than from the West—which, indeed, would be more in accordance with the vague Aztec and Maya traditions. On the Pacific side, as Mr. T. A. Joyce aptly points out, a high mountain-range and wide tracts of forest form a serious obstacle to any ingress; nor, as he observes, are there found in that region any remains except such as are "obviously late reflections of Maya culture."

The one argument of the opponents of the theory that Maya culture is indigenous which appears at first sight to have any real weight, has been left to the last. It is, briefly, that as that culture bursts upon us full-fledged, and as there is no trace at all of its rude beginnings or of the steps by which it has been gradually evolved, it must, therefore, have been imported from without. Is this contention valid? It has been seen, if Doctor Spinden's conclusions be accepted, that the period of archaic Maya *florescence* lasted roughly from about A.D. 70 to A.D. 612, and that though the remote starting-point of their calendar dates back to 3373 B.C. there have been no monuments *hitherto found* bearing any date which can be regarded as historical till we come well within the ninth cycle. It has, on the other hand, also been seen that the astronomical knowledge of the Maya, as indicated by their calendar, presupposes an extremely long period of previous observation, and the same remark applies in the case of their highly-developed writing. A further factor indicating great antiquity is that of the Maya language. Centuries before the Conquest this had been already divided up into numerous dialects containing wide points of distinction, all of which, however, bore a relationship to a common source. The amount of time necessary for the divarication of these dialects one from another indicates a long period of separate existence for the different communities that employed them, and points to a remote date for the dismembership of the original dominant race.

The answer, then, to those who deny that Maya culture is indigenous because we have as yet found no traces of its beginnings or gradual development, is that it is far too soon to dogmatise on the matter at all. Only recently an entirely new group of ruins of considerable extent has been found in British Honduras. Is it unreasonable to suppose that in the hundreds of square miles of forest in Yucatan and Guatemala still entirely unexplored there may be many more, including, perhaps, inscribed monuments with dates far earlier than any yet interpreted which may lead us back in the direction of that mysterious starting-point 3373 B.C.?

"Will You Step Into My Parlour—?"

By T. H. Savory.

Many people have an unreasoning horror of spiders—which is a mistake. The spider is decidedly useful as an enemy of the germ-laden fly. This article shows what a number of problems still remain to be solved about the spider and may suggest useful observation work.

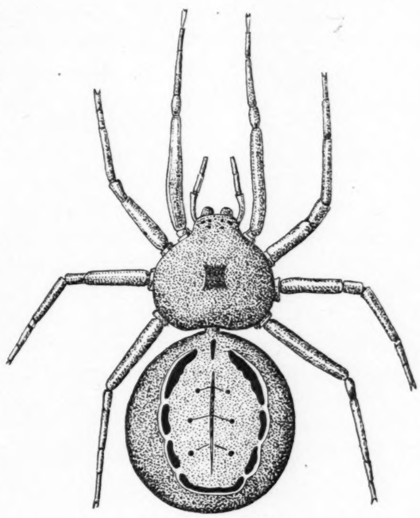
"WHERE can spiders be found?"—a common enough question, whose answer is, most briefly, "Everywhere." In a general sense this is true, for in every country and at every time there are spiders in most imaginable situations, except in the sea.

But not always the same spider.

Malacologists have always been familiar with this phenomenon. Many species may inhabit a certain area, but each is to be found in its own particular station. A given species may perhaps be confined to a few square yards, within which space it is abundant, while it is utterly useless to look for it anywhere else. Seekers after spiders meet with exactly the same state of affairs.

Spider-hunting.

We may explain these facts in a form of words by saying that the mollusc or spider is very sensitive to changes from the optimum of environment, but when we examine them more closely, we find that they present an attractive array of problems and, at the same time, show mercilessly how little we really know about the conditions of existence of the living invertebrate.



ZYGIA ATRICA.

Follow briefly the activities of one who attempts to determine the spider population of his own neighbourhood. Several of the commoner species are found in the sheds and stables at home, and occur again, but with striking additions, in the conservatory and greenhouses. Running in the open fields are many wolf spiders, but to complete the survey of this family alone, the banks of rivers and streams, the sandhills, and the seashore must also be searched. An entirely different bag is the reward of beating and sweeping the hedges and lower branches of trees. A multitude of the smaller fry are taken by sifting dead leaves, pine needles, moss and grass roots. Quarries harbour others, heather conceals many seldom seen elsewhere, others again are hiding beneath the bark of trees. Many of the rarest are found under stones bedded in the earth, one species, and only one, lives in fresh water, a few are lodgers or welcomed guests in ants' nests, and finally, if the mountains be climbed, there are found spiders that do not consent to live much below the thousand-foot contour.

All this goes to show how numerous and how diverse are the habitats that spiders favour, but the conclusion of the whole matter is only heard when the distribution of the different families among them has been realized. Although this is a big subject, a few definite examples well illustrate its nature.

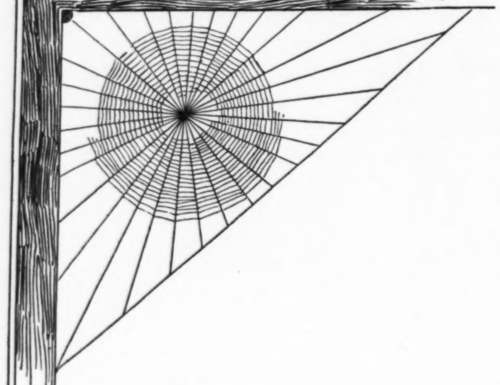
Collecting.

There is a family of the genus *Epeiridae* (the family recognized by the familiar and beautiful orb web) known as *Zygia*.* In Great Britain it is represented by three species. One of these is *Z. stroemii* and is rare; the other two, *Z. atrica* and *Z. x-notata*, are exceedingly common, being both numerous and widely distributed. They are betrayed at once by the peculiar character of their webs, in which the spiral thread is missing from two neighbouring segments, leaving an isolated radius which communicates with the owner's hiding-place. These two species are so closely allied that the separation of the two females, lying on the laboratory bench, is a matter demanding the greatest care. But in collecting them it is found that *Z. atrica* is taken out of doors, from bushes and shrubs, while *Z. x-notata* lives in the angles of doorways and window frames, both inside and outside the house, but never far removed from buildings.

It is quite useless to look for either in the places inhabited by the other, and the particular problem under discussion is emphasized by the close structural resemblance between the two species.

* More commonly as *Zilla*, but the type of *Zilla*, *Z. dioidea*, is properly an *Epeira*.

Two hypothesis might be framed to explain the facts: either that there is no connexion between structure and environment; or that each spider receives from the station it adopts, and would lack in the station it abandons, some advantage in the struggle for life. The former hypothesis is clearly untenable, for its acceptance would practically amount to a denial of the existence of the adaptation of the organism to its environment. The latter, despite an unpromising outlook, must therefore be examined more closely.



WEB OF *ZYGIA X-NOTATA*.

Each of these two closely-allied spiders is receiving, we assumed, from the environment it has chosen, some benefit or advantage that the other despises. This benefit must be such that it is not appreciated by a structural difference, for such differences do not exist or, if they do exist, are not yet recognized.

Environment.

It is, then, only possible for the environmental differences to be correlated with differences in habits, and this is more conceivable. It may be that it is a difference in actions, or in response to external change, that confines the two species to their separated spheres. The hypothesis is capable of being tested by a sufficiently intensive study and comparison of the habits of the two species, a study which has not yet, I think, been undertaken. It is not a very satisfactory theory, for it suggests a lack of connexion between habits and structure which is certainly unacceptable. Nevertheless, it is possible that the reactions of two spiders might vary without producing a corresponding and obvious difference in their anatomy.

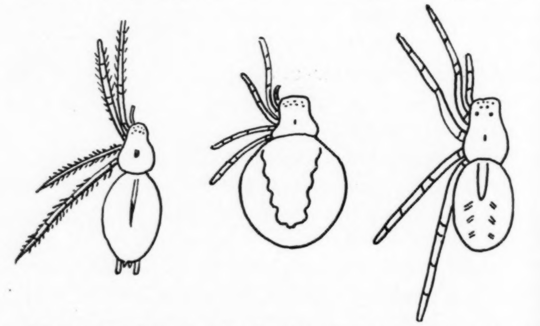
The relationship between the spider and its environment is threefold, inasmuch as the latter provides the former with (1) food and water; (2) warmth and shelter; (3) concealment from enemies. If we apply these considerations to the case of the two *Zygia*, we do not derive much comfort. The prey of spiders is most frequently a " fly " of some sort, but in truth a spider will feed upon anything that it can catch. The spider seldom, if ever, reads the menu with discrimination, and it is exceedingly difficult to see why, from this point of view, a window-frame should be better than a bush.

Mysteries of Choice.

It is equally difficult to choose between the two sorts of surroundings for any other reason. They both supply good concealment, for the spider rests in a silk nest of its own manufacture, which may be under a leaf or in a window corner. The fact that *Z. x-notata* as often spins outside the window as inside, and as often in unwarmed sheds as in houses, destroys the attractive theory that this species requires a higher temperature for its comfort.

And, in fine, whatever there be of contrast between the two situations, it must satisfactorily account for the complete and invariable absence of either species from the habitat of the other.

The genus *Tegenaria* provides another good instance of the same phenomenon. *T. derhamii* is the commonest of house spiders all over the temperate world, and it is never found away from houses. *T. atrica* is usually a house dweller, but is sometimes found in the open air; while conversely, *T. guyonii* usually lives out of doors and only occasionally in houses. Finally, *T. campestris* never lives indoors at all. This is a set of facts of distribution to which it is exceedingly hard to fit any explanation. There is nothing in the



From left to right:—*Tegenaria.*—Very long legs with long hairs; two very conspicuous spinnerettes. *Epeira.*—Rounded abdomen with leaf-shaped mark; legs short and stout. *Lycosa.*—Eyes in three rows; legs moderate; median stripe on abdomen.

structure or known habits of these four *Tegenaria* to suggest that they should form successive terms of a series, if we may so express it.

Similar considerations apply to *Argyroneta aquatica*, the well-known water spider. It has adopted a mode of life which not a single one of the many thousands

of other spiders has imitated, and yet there is not one detail of its anatomy which suggests that it lives in water. Indeed, a mere morphologist, who never undertook field work, would have no inkling of the fact, and would probably strenuously deny its possibility.

A final example is provided by the genus *Lycosa*, of which there are eighteen British species. Eight of these are generally distributed, and include all those sombrely-coloured wolf spiders that, oftentimes in immense numbers, scamper away from us and our spaniels as we walk over the fields and pastures. Of these eight, one, and only one, is arboreal and is ever to be found on the branches of trees and shrubs, one is riparian, living among river shingle, and one is silvan and prefers the shade of woods. Another *Lycosa* is semi-marine, and occurs only by the sea.

Unexplained Problems.

When one emphasizes the fact that these differences of habitats are not represented by corresponding differences of structure, one is almost driven to question the entire validity of our present methods of classification. Such systems as we use seem to stress an architectural similarity which may be entirely fortuitous; at the same time they completely conceal differences in the manner of life which are the essential characteristics of the animal as a living organism. But no one can deny the facts of morphology, to which we appeal for evidence of taxonomic relationship: the positions of eyes and lengths of legs, the carpoblems, the mastidions, the trichobothria—these are patent and unavoidable. It is only left for us to realize that while we can perceive these structural details, we remain vastly ignorant of their active significance. We can never answer the question "Why?"

CORRESPONDENCE.

To the Editor of DISCOVERY.

(Referring to Article "Synaesthesia," by Dr. Eric Ponder, in the April number of *Discovery*, page 136.)

SIR,

There is no doubt that this association of senses is quite common, and not only applies to musical sounds but to many other impressions, some of a most diverse character.

If anyone gives way to this tendency to associate sounds with colours, etc.—useful as the process may be for mnemonic purposes—it is easy to allow such associations to obsess one's conceptual field, and to establish almost a tyranny over thought and aesthetic judgments very much akin to prejudice.

This, however, does not affect the scientific interest of such phenomena as a branch of psychology.

The point I would draw attention to is the comparatively frequent appearance of some theory or experimental demonstration of a connexion between colour and sound. The literature of the last 200 years contains many such schemes, but in every case, as far as the writer knows, the analogists have compared musical notes with colour.

As pointed out in the writer's "Simultaneous Tonality" (1916), man possesses no definite colour emissions expressive of his emotions, comparable with the voice in sound. He thus falls short of the overrated chameleon; although the female sex used to be credited with blushing a rosy red or blanching to a deathly pallor, it is believed that these attainments are now somewhat out-of-date.

In introducing a handy system of colour names for the common musical intervals the writer based the system on a definite analogy.

If we represent intervals by colours, we have something which in both cases can be recognized apart—to a great extent—from saturation and a certain amount of variation.

The addition of white to any colour merely alters its saturation, and does not (within reasonable limits) affect its hue. This property is analogous to that of the octave interval, in merely rearranging (inverting) any other given interval.

Taking the first five intervals of the Harmonic Series, such as are commonly employed in music, the following colour names and symbols are attached :—

Interval.	Colour name.	Symbol.
Octave	White	W
Perfect Fifth	Blue	B
Perfect Fourth	Red	R
Major Third	Green	G
Minor Third	Violet	V

With the corollaries :—

Major Sixth	Yellow	Y
Minor Sixth	Mauve	M

The symbols are simply the initial letters of the colours.

It will be seen that the respective intervals added together give an interval corresponding with the respective colours similarly added. Thus, for instance, red, green, and violet make white. So do the Perfect Fourth, Major and Minor Thirds.

There is little difficulty in recollecting the R.G.V. Scheme of the tri-chromal theory (*pace* the latter's critics). At any rate a piece of glass in the sun, or oil on a puddle, will soon recall the order, and it will be seen that the analogy has the merit of logical coherence.

There is nothing metaphysical in such a scheme, nor is it put forward as a basis for a "colour organ" or aesthetic method, although anyone is welcome to the idea.

It is simply a matter of saving labour in writing, speaking of, and printing the names of musical intervals, and as such is submitted to the readers of *Discovery*.

92, Cheriton Road, Folkestone. JOHN L. DUNK.
24th April, 1925.

THE PEACH BORER.

THE damage done to peach trees in the U.S.A. by this insect during the past summer amounts to no less than $6,000,000. To prevent a similar loss next year the Washington Department of Agriculture recommend the farmers to paint all their trees during this autumn with a solution of Para dichlor benzene, one of the simpler benzene derivatives, as it has been found by experiment that it is very effective in killing the pest.

Book Reviews.

Chemistry to the time of Dalton. By E. J. HOLMYARD. (Oxford University Press. Humphrey Milford. 2*s*. 6*d*. net).

The historical continuity of chemical thought is little known and too little appreciated. This book gives without unnecessary discursiveness a clear picture of the gradual evolution not only of a widening range of substances, but of a clearer conception of the theory of chemistry and the change from mystical empiricism to reasoned experiment.

The most interesting section of the book is undoubtedly the new light thrown on the work of the Islamic alchemists, particularly Abu Mosa Tabir ibn Hayzan, whom we know as Geber. Mr. Holmyard's researches show that many early Latin MSS. which have been thought to be translations of lost Greek originals or later spurious inventions are, in point of fact, translations of Arabic MSS. It is curious to note how from the earliest days English names occur and what a splendid historical tradition our country can command. The book is extremely interesting and fulfils its purpose in that it gives the student—not only of chemistry but of history—a clear view of the general state of European chemical knowledge at any given period.

It is welcome news to learn that it will be followed by a second volume devoted to chemistry in the nineteenth century, for these little manuals of the history of science are important to all who wish to build up a clear mental picture of the long path by which our modern standards of scientific thought have been reached.

Œuvres de Pasteur. (Three Volumes). By PASTEUR VALLERY RADOT. (Masson et Cie. 100 francs per volume).

Doctor Vallery Radot, who is Pasteur's sole surviving grandson, has been engaged for several years on the official collected works of his grandfather, Louis Pasteur. There is no more honoured name in the records of French science, and Pasteur was one of the outstanding figures of his century not only in his own land but throughout the true national field of science. He began as a chemist and there developed that sound scientific technique of theory, experiment and proof which he was later to apply in fields we should to-day class as biological rather than purely chemical. Later he turned to medicine and his wonderful researches on preventive vaccines.

The first volume is devoted to Pasteur's early crystallographic researches for which he was awarded the Rumford Medal by the Royal Society. The outstanding discovery was the connexion between right- and left-handed crystallization systems of salts of racemic and tartaric acids. Patient research enabled Pasteur to discover the law which accounted for the difference between these two almost identical acids. From his original discovery much later work of importance was done by other investigators. Pasteur's early discovery of this principle of "molecular dysymmetry" had a profound influence on all his thought, even during later and apparently unrelated work in other fields. To the last he believed that we should find that the connexion between inorganic and organic depended on this principle. It is a problem still unsolved, and we may yet find that this great master, with his gift of vision as well as wonderful capacity for actual scientific thought, was right.

The research on the organic acids led him to his even more important work on the fermentations of vinegar and wine. To-day we hardly grasp the conditions of scientific thought of sixty years ago. The theory of the spontaneous generation of life still enchained majority thought. Dogma was as a lion in the path of the search for truth. Pasteur, working logically and inexorably, had not only to demonstrate the truth of his bacteria or living-organism theories, but also to force a not too receptive scientific world to abandon the belief of their time and accept a new and revolutionary theory.

To-day these matters are the foundation of enormous wealth both in knowledge and more literally in industry and the applied arts. It is not until we read the original work of Pasteur that we glimpse what we owe to him. Much of his lesson is still needed to-day, and to read his work is to receive a lesson in true scientific method.

The volumes are admirably edited and noted and the chain of coherence—not an easy thing to recapture in a mass of scientific papers—is preserved throughout. Doctor Vallery Radot is to be complimented on the way he has carried out an extremely difficult task. The further volumes dealing with Pasteur's work in relation to infectious disease are now in preparation and will appear shortly.

Steel. By COLONEL ROUELLE. Translated by ALFRED CHAPPLE, M.A., Engineering Laboratories, Cambridge. (Geoffrey Bles. 5*s*. net).

Cast Iron. By COLONEL ROUELLE. Translated by ALFRED CHAPPLE, M.A., Engineering Laboratories, Cambridge. (Geoffrey Bles. 5*s*. net).

These two little books can be most heartily recommended. They fill a gap which has been felt by nearly all students of engineering. In the past there has not been any small concise textbook which gave the detail facts and broad outline of the manufacture, treatment, testing and general use of these all-essential materials. There have been gossipy inaccurate popularized versions dealing with dreary historical developments and giving no useful knowledge of the working of to-day. There are ponderous and disquieting textbooks which assume that the reader already knows a very great deal about the metallurgy and practice of iron and steel. But there never was a good little general introduction to the subject suitable, say, to the university-trained man starting on a year of practical experience at a steel plant or the apprentice at an engineering works.

These books, translated from the French, have a peculiar quality of clear thinking, simple and concise explanation, and logical sequence. They give the outline and all the detail that is necessary for the individual who wishes to gain a general grasp of the why and wherefore of the processes going on. They are excellently adapted for general reading, and it is to be hoped that further volumes of equal standard will be added to the series.

The books cover not only the preparation of cast iron and steel according to modern practice, but a very clear summary of the detail of casting the various grades, the processes of wire-drawing, stamping, pressing, and heat treatments.

These books can be very genuinely recommended, for they compress the maximum of most useful knowledge in extremely readable form.

Junior Technical Electricity. By ROBERT W. HUTCHINSON, M.Sc., A.M.I.E.E. (University Tutorial Press Ltd. 4*s.* 6*d.* net).

This small textbook is suitable for first-year students in evening technical schools.

The Psychology of Emotion, Morbid and Emotional. By JOHN T. MACCURDY, M.D. (Kegan Paul. 25*s.* net).

A painstaking study of manic-depressions and psycho-pathological states is not, despite the publishers' assurance on the wrapper that it is written throughout in a way to appeal to the general reader, suitable for general reading. The student of psychology may find the book interesting for it discusses the advanced abnormality of the insane rather than the usual borderline cases which have not reached the critical point of qualifying for hospital treatment. The general reader interested in psychology will seek in vain for any solid matter. The author's theory is that the problems of emotion in the normal and in the abnormal mind are actuated by the same machinery and obey the same laws. This idea may be new to some schools of psychologists, but is very much what most people unskilled in the new magic had always assumed to be the case. The medical reader will find little detail of technique in spite of the voluminous case records.
J. McS.

Modern Inorganic Chemistry. By DR. J. W. MELLOR. (Longmans, Green & Co. 12*s.* 6*d.* net).

The new edition of Mellor contains 1,123 pages, and represents a remarkably substantial volume at a very low price. It is well bound and printed on good tough paper. It may seem strange to stress these details of production, but the book is a well-known and established class-book. Books of this nature need to be durable and value for money, and many post-war editions of class-books have been so poorly produced that authorities have had serious complaints from student purchasers.

Few books on chemistry possess the scope and vision of Doctor Mellor's work. It is compendious in itself, but it posesses the all-important quality of inspiring the student with a desire to know more. Above all it is admirably up-to-date, without either shirking the serious issues of modern chemical thought or becoming loosely speculative. It can be generally recommended and justifies its title and its well-earned reputation.
J. M.

The Life after Death in Oceania and the Malay Archipelago. By ROSALIND MOSS, B.Sc., Oxon. (Oxford, Clarendon Press. 1925. Pp. xii, 247. Price 14*s.* net).

Life after death is a subject of perennial interest to man, whether primitive or civilized, believer or agnostic. Miss Moss has gathered together and classified all the beliefs and practices relating to the subject held by peoples who, though scattered over a wide area and racially distinct, have much in common in their culture. The culture of Oceania is obviously composite. A series of migrations, by which layer has been superimposed on layer, has produced a confusion of race and custom which it is the hope of the ethnologist ultimately to disentangle. Sir James Frazer in so much of his great work " The Belief in Immortality" as has already been published, has dealt with part of the material from the ground covered by Miss Moss, but the work of the two authors does not overlap. For while Sir James Frazer's interest is philosophical, dealing analytically with the character of the belief, Miss Moss discusses its distribution and ethnological significance according to its varying type. For instance, she shows the essential difference between two types of belief in an underworld. The underworld among the Southern Melanesians is connected with volcanoes, and is a place of gloom, whereas among the Papuans it is not gloomy, and it is connected with the entrances of caves. In the same manner the belief in the journey upon which the soul is often held to enter after death may sometimes be used as evidence of racial migration and even point out the line which that migration has traversed according to the direction in which the home of the dead is said to lie. It is interesting to note that while the home of the dead may be an underworld, or be situated on this earth, it is rarely in the sky and, when it is placed there, more often than not it is to be traced to Mahommedan influence. An example of Malayan influence is to be seen in the belief in a soul boat in which food and offerings are placed with the idea that they will be used by the dead man in his voyage to the other world. It is not a widely distributed belief, but it is interesting because it undoubtedly is derived from the Malayan custom of expelling evil spirits annually by sending them off in a boat which drifts out to sea. Miss Moss's analysis of the reasons which prompt relations to place food and valuables in the grave of the dead is a useful corrective to the popular idea that these articles are *invariably* intended for the use of the dead man, and at the same time serves to show how different lines of belief may converge in a single practice. The author is to be congratulated upon having produced a very useful and suggestive book.

The Natural History of Wicken Fen. Part II. Edited by PROFESSOR J. STANLEY GARDINER, F.R.S. (Bowes & Bowes. 6*s.* net).

Few pieces of work are of such general interest and utility as a natural history survey of a definite English locality. The studies of Wicken Fen life which are being carried out by a group of very competent workers under Professor Gardiner, are not only interesting in themselves but, what is even more important, they are presented in an eminently readable form. This is far more important than is generally realized, for it makes this very vital difference—in place of being a series of stilted little monographs full of scientific jargon, the corporate work acquires a definite style and value; the various sections by individual workers fall into place as a coherent whole, and the book being written in clear plain English becomes valuable to keen students and readers in general who may for a variety of reasons only be able to assimilate knowledge when it is clearly set out in their mother tongue.

The work gains by it, for in place of being only of interest to a localized group it becomes a model and an incentive to other groups of workers to produce similar work. The authors too gain by it, for the world at large is not slow to recognize that clear expression and clear thinking go together.

The eight sections of this part cover a wide field of insect life, the mollusca, hiradinea, the phyto-plankton and the hydrogen-ion content of Wicken Fen waters. Each section is more than a catalogue, for it gives the reader an idea of the interest and special points of research in each particular field. The book deserves the attention of field-naturalists in general, and can be heartily recommended to local societies as a model. Further parts will be published later as work proceeds, and anybody who has become acquainted with the work will not be slow to welcome them.

Radio Beam and Broadcast. By A. H. MORSE, A.M.I.E.E. (Ernest Benn Ltd. 12*s.* 6*d.* net).

This is one of the most useful books on the history of wireless. It is invaluable to inventors, designers, and commercial firms, for it gives a complete summary of the basic patents and shows that quite a number of ideas thought to be covered by patents

are invalid on account of prior publication. Many matters thought to be protected are open to any inventor or manufacturer as the patents have long since expired.

The book is not only useful—indeed, invaluable—as a work of reference, but also gives perhaps the most accurate account of the true development of wireless yet written, and a very complete history of American patent records.

Plants and Man. By F. O. BOWER, Sc.D., LL.D., F.R.S. (Macmillan. 14*s.* net).

This little series of essays written originally for publication in a provincial paper bring some of the material of plant biology before the non-technical reader. The author's object is to interest people in plant life, and his book is pleasantly written without going into any great technicality. It should prove successful and can be recommended as " light scientific reading."

Why the Weather? By CHARLES F. BROOKS. (Chapman & Hall. 8*s.* 6*d.* net).

The weather is a subject of inexhaustible interest even in America, and this book by an American author represents the popularized version of lectures given to a class of students in meteorology. It is not the usual semi-textbook, but purely popular and gives a very good elementary survey of the wide range of causes which affect our even more variable climate. The material is substantially accurate and conveys its lessons in gossipy form, although being essentially an American product the idiom and the parallel illustrations are at times unfamiliar. Will be read with interest by many amateur I.T. meteorologists.

The Hawke Battalion : Personal Records of Four Years, 1914-18. By DOUGLAS JERROLD. (Ernest Benn. 7*s.* 6*d.* net).

This is an entirely unorthodox book. It hides behind a conventional title a far better study of the reaction of the ex-civilian fighting-man to the ways of the professional soldier than has yet been written. Most battalion histories are not even interesting to the men who were in the battalion. They are, as a rule, dreary compilations slung together by a civilian hack out of " official " war diaries and the dust of " records." Few more misleading sources exist, for the war diary—as soldiers know – does not give either truth or a picture.

Mr. Jerrold has been fortunate not only in his own intimate personal association as adjutant of the Hawke Battalion R.N.D., but in his access to personal documents of greater value than anything likely to be found on official record. He gets not only the facts, but the true spirit of the unit. As a result his book is readable from cover to cover by people who have no association with the battalion, but who are interested in books of contemporary history which give a true picture.

The Royal Naval Division drew many of its personnel from the universities. These men may be fairly taken as representative of the finest type of youth in the country. Their view of the war and the corporate effort represented by the work and individual spirit of a battalion is accurately given in this book. It is dispassionate. There are neither elegies nor neurotic wails. A stinging epilogue on literature and the war blows away the poison gas of those who bade us forget our dead and acclaim those who evaded service as the only brave men. " Was it not at least as plausible," the author asks, " that the real heroes were those who fought, but without enthusiasm, especially as it seemed clear that these few alone could claim alike the favours which public opinion still reserves for those who fought and the blessings promised by the Prince of Peace to those who do not ? "

The obsession that the important feature of war is its effect on the superior sensibilities of a few egotists has obscured the fact that it is the mass reaction which alone is worth study. The psychologist, historian, or moralist will find this book the ablest " case record " of a corporate unit that has appeared. Good as it is as a history, it is further a work of the highest importance as a book on the most important factor in war—morale.

The Principles of Thermo Dynamics. By G. BIRTWHISTLE, Fellow of Pembroke College. (Cambridge University Press. 7*s.* 6*d.* net).

The field of thermo-dynamics is one which is gradually playing a more and more important part in various branches of science. This book is suitable for the student who has reached a standard where not too advanced mathematical interpretation of physical principles is within his capacity. It is clear, concise, and founded on a series of lectures.

Down the Grand Canyon. By LEWIS R. FREEMAN. (Heinemann. 15*s.* net).

There is a special and particular charm about travel books written by people who have " done things " in place of the garrulous globe-trotter. Lewis R. Freeman makes a hobby of rivers, and writes of his adventures with a solid knowledge of the meanness of running water that strikes a responsive echo in anyone who has handled pole or paddle in unknown waters.

His work was mainly connected with the geological survey of the U.S.A. and the siting of dams to control irrigation systems at the mouth or sink of the Colorado river. The work carried him into the vast rock cleft of the Grand Canyon and into the sunny bayous of the open delta. He was handicapped in some of his later exploration work by having only the crudest and most unreliable form of craft, although it would appear that the nature of the work would have justified the expenditure of public monies on adequate equipment.

The book is extremely readable and gives an excellent idea of the very real ardours of " fieldwork " in the mapped but little-known regions of the U.S.A.

Useful Aspects of Geology. By S. T. SHAND, D.Sc., Professor of the University of Stellenbosch, South Africa. (Thos. Murby. 7*s.* 6*d.* net).

A book on geology meant to be useful to people of little scientific knowledge and no special training is not an easy work to write. Geology bristles with forbidding jargon but here, at last, one may almost say, is a book written by a professor which can be read by a prospector. It is a book which earns *Discovery's* unstinted commendation. It is clear, simple, and accurate, and written in that very best of all styles, plain English. It is purely an outline of geology, but it gives exactly what the non-technical student requires, a general survey of the broad aspects of the subject which will enable him to approach more specialized books with the necessary elementary knowledge to render them comprehensible.

In essence it shows how an elementary knowledge of geology may be turned to account and it includes a well-selected list of more advanced books dealing with specialized aspects. It will be particularly useful to the overseas reader.

Practical Advice for Inventors and Patentees. By C. M. LINLEY. (Sir Isaac Pitman. 3*s.* 6*d.* net).

Patents are expensive, and anyone contemplating taking one out is likely to save a great deal more than the price of this little book by reading it.

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